FLAT FLOORS AND APPLE BOWS : EVIDENCE FOR THE EMERGENCE OF AN IMPROVED MERCHANT VESSEL TYPE FROM THE NORTH OF ENGLAND DURING THE EIGHTEENTH CENTURY

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by

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Submitted in partial fulfilment of requirements
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Abstract

This study provides a detailed description of eighteenth-century English merchant vessels and tests the hypothesis posed in 1962 by Professor Ralph Davis that during the eighteenth century a significantly improved merchant vessel type emerged in England that required a smaller crew but carried more cargo than previous English vessels, thus boosting England's position as one of the world's greatest maritime nations. The study also develops vessel descriptions that will assist nautical archaeologists in identifying and classifying shipwreck remains. Merchant vessels were chosen for study because of the relative scarcity of scholarly publications on commercial vessels from the age of sail and because of the wealth of new archaeological data on English merchant vessels that has emerged during the past two decades.

A wide range of historical and archaeological information was reviewed and, in spite of initial indications to the contrary, it was possible to amass an incredible wealth of information on seventeenth- and eighteenth-century merchant vessels built in England or her colonies. This study presents descriptions, illustrations and draughts of a variety of eighteenth-century English merchant vessels, along with a number of archaeological examples that demonstrate a richly diverse range of hull forms and rigs. Much of the detailed archaeological information was recovered from a group of sunken vessels from the Battle of Yorktown, 1781, especially site 44YO88, which proved to be an English collier built in 1772 and leased as a naval transport.

There is much evidence to suggest that the highest quality, most capacious, most efficient, most long-lived, most stable and strongest merchant vessels in England during the eighteenth century were being produced in the northern ports where the primary export was coal. Rather than representing a radical new design, those colliers appear to have embodied

the best compromise of qualities for a bulk cargo carrier, qualities that were already known and appreciated a century earlier, but which may have found a new harmony in the collier. Even with the many descriptions and widespread praise focused on the flat-floored, apple-bowed colliers of northern England, there does not appear to be sufficient evidence to assert that English colliers represented, in the eighteenth century, a radically improved vessel type. However, it seems reasonable to assume that those sturdy, reliable vessels successfully satisfied the economic needs of the times and provided a new source of pride for English shipbuilders. It also seems reasonable to speculate, in retrospect, that their appearance, in the large numbers that flowed out of northern yards in the eighteenth century, improved the overall efficiency and quality of the English merchant marine.

I, John D. Broadwater, hereby certify that this thesis, which is approximately 100,000 words in length, has been written by me, that it is the record of work carried out by me and that it has not been submitted in any previous application for a higher degree.

Date: ______________________ Candidate: ______________________________

I was admitted as a research student under Ordinance No. 12 in October, 1989 and as a candidate for the degree of Doctor of Philosophy in October, 1991; the higher study for which this is a record was carried out in the University of St. Andrews between 1989 and 1997.

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I hereby certify that the candidate has fulfilled the conditions of the Resolution and Regulations appropriate for the degree of Doctor of Philosophy inthe University of St. Andrews and that the candidate is qualified to submit this thesis in application for that degree.

Date: ______________________ Supervisor: ______________________________

Acknowledgments

This study of eighteenth-century English merchant ships, developed over more than two decades, was influenced by so many individuals and organizations that it is nearly impossible to extend adequate credit and thanks to them all. The study had its genesis in a series of conversations with John O. Sands, then curator of collections at The Mariners' Museum, Newport News, Virginia. He had just completed a master's thesis on the shipwrecks from the Battle of Yorktown (Virginia), 1781, many of which were transports leased from merchant shipowners. The subsequent surveys and excavations at Yorktown that we were able to organize provided the incentive and initial data for the present study.

The Yorktown Shipwreck Archaeological Project, conducted during the period 1978-1990 by the Virginia Department of Historic Resources, produced significant archaeological data on eighteenth-century British warships and transports. As principal investigator I directed the excavation, research and analysis. The focus of the Yorktown Project was an unidentified shipwreck, 44YO88, an extremely well preserved British transport vessel that yielded detailed information on the construction and function of eighteenth-century merchant ships.

As stated above, the initial inspiration for investigating the Yorktown shipwrecks was John Sands's scholarly research which, in 1983, culminated in his excellent book, *Yorktown's Captive Fleet*. William M. Kelso and Ivor Noël Hume were largely responsible for initiating Virginia's underwater archaeology program and have remained faithful mentors, providing encouragement, wise counsel, frank criticism and friendship. They, along with then Executive Director Junius R. Fishburne and Landmarks Board member Mary Douthat Higgins, established the state underwater program and helped secure funding for

the Yorktown research. The Department continued to support the project throughout, but never with the same level of commitment and enthusiasm as when this group was in charge.

John Sands not only provided the historical foundation for this project, but also faithfully served as historical advisor, consultant and friend throughout the project. Joseph Goldenberg and David Syrett were early advisors who contributed historical data and references that proved invaluable to this study. Syrett was particularly helpful in suggesting how to locate merchant vessel information in the massive Admiralty Collection in the Public Record Office, Kew, London. Others in the United States who provided helpful information included Robert Caverly, David Moore, Thomas Oertling, Warren Riess, Alan Saltus, Duncan Stuart, David Switzer and James Whittenburg.

The project also benefited from the assistance of the Institute of Nautical Archaeology (INA), especially from its president and director, George F. Bass, and its ship reconstructor, J. Richard Steffy. George Bass was particularly helpful and encouraging to me, offering frank and constructive advice throughout the project. It was he who inspired me to become a professional archaeologist. INA conducted two very successful field schools at Yorktown, in 1976 and 1980, both of which generated extremely significant results; additional INA students and former students participated intermittently throughout the project.

Early in the project, I was able to establish a valuable partnership with the Program in Maritime History and Nautical Archaeology at East Carolina University (ECU), Greenville, North Carolina. ECU Maritime Program co-directors William N. Still, Jr. and Gordon P. Watts, Jr. shared my conviction that the Yorktown Project would provide excellent opportunities for training students in underwater archaeology field methods. As soon as the cofferdam was completed in 1981, a team of students and faculty from ECU conducted the initial excavation of 44YO88 as a field research project. Gordon Watts, who had been one of the first researchers to offer his assistance on the Yorktown shipwrecks, continued to direct field schools at Yorktown throughout the excavation.

Special thanks are due the project staff, especially those involved in the final, arduous phase of excavation and analysis. John W. "Billy Ray" Morris III, assistant project

director for site operations during the last phase, was primarily responsible for the recording and documentation of the hull remains, and he prepared many of the excellent, detailed description and drawings of the hull from which much of Chapter 5 is derived. Marcie Renner, assistant director for conservation and curation, contributed immeasurably to the research and reporting, as well as to the conservation of finds. Other staff members during the final phase of the proejct were Linda Brown, David cooper, Bruce Terrell and Eri Weinstein. Also, Bates Littlehales, photographer for *National Geographic Magazine*, went far beyond the call of duty in extracting exciting photographs from the usually murky Yorktown cofferdam waters, and we considered Bates to be an "honorary" staff member.

For their willingness to provide very helpful and constructive comments during this study, my thanks go out to Roderick Mather, John O. Sands and Gordon P. Watts, Jr.

The Yorktown Shipwreck Archaeological Project received such extensive and varied financial support that it is impossible to acknowledge all those who assisted. Certainly, special mention must be given to the Virginia Department of Historic Resources, under whose aegis the project was conducted. The National Endowment for the Humanities provided almost continual funding and encouragement throughout the project. The construction of the cofferdam would not have been possible without a Maritime Preservation Grant from the U. S. Department of the Interior (co-administered by the National Trust for Historic Preservation), for which matching funds were obtained from the Commonwealth of Virginia, the National Geographic Society, the County of York, the Norfolk Foundation, and numerous corporations, foundations and individuals. I must add my personal thanks to the Caird Research Committee, National Maritime Museum, Greenwich, which, in 1990, awarded me a supplementary research grant that made it possible for me to complete my project research in the United Kingdom, and to the National Endowment for the Humanities, which, in 1992, following the abolishment of the Virginia archaeology program and my position with the state, awarded me an individual grant for the completion of research and reporting on the Yorktown Shipwreck Archaeological Project.

Almost all of the data utilized for the present study was obtained in the United Kingdom During several research trips to the United Kingdom I received gracious and enthusiastic assistance from numerous extremely knowledgeable advisors, including Valerie Fenwick, Honor Frost, Robert Gardiner, Basil Greenhill, Roger Knight, Brian Lavery, David Lyon, David MacGregor, Peter Marsden, the late Keith Muckelroy, Dawn Muirhead, Ray Sutcliffe, the late Joan du Plat Taylor, Ian Tyers, and Jane Weeks, London; Jonathan Adams, Andrew Fielding and Margaret Rule, Portsmouth; Adrian Osler, Newcastle; Harold Brown, Clifford Felgate and David Wharton, Whitby; Harry Fancy, Whitehaven; and Martin Dean, Colin Martin, Ian Oxley and Robert Prescott, St. Andrews. In addition, John and Phillip Tindall graciously made available many valuable documents from the eighteenth-century shipbuilding firm owned and operated by the Tindall family of Scarborough. A particularly exciting item was the log book from the Tindall vessel *Emerald*, sunk during the Battle of Yorktown.

Not only did I receive valuable scholarly assistance in the United Kingdom, but warm friendship and hospitality as well. This is especially true of David Lyon who, in 1979, first welcomed me to the National Maritime Museum in Greenwich, producing reams of pertinent data, sheaves of references, and scores of introductions to other researchers. Since that time, David has continued to assist me with my research, and he and his wife, Eleanore, have offered food, shelter, entertainment and—most of all—a friendship that has already outlasted the Yorktown Project. I also value the hospitality and friendship I have received from Martin and Judy Dean, St. Andrews, Harry and Mary Fancy, Whitehaven, Dave Wharton, Whitby, and all the others who made my research both productive and enjoyable. The assistance I received from David MacGregor can not be underestimated; he is undoubtedly the leading authority on British merchant sailing vessels, and he generously shared his knowledge and provided a wide range of information and advice throughout this study.

Research in Europe was also fruitful, thanks to the assistance of numerous very knowledgeable and helpful people: In Denmark: Ole Crumlin-Pedersen, Viking Ship Museum, Roskilde; in Germany: Detlev Ellmers and K. Schietzel, German Maritime Museum, Bremerhaven; in Holland: Gerret D. Van Der Heide, Enkhuizen Museum, Enkhuizen, M. Bouma, Prinz Hendrik Maritime Museum, Rotterdam, and Jaep Morel and Karel Vlrerma, Ketelhaven Museum, Ketelhaven; in Norway: Sven Molaug and Bard Kolltveit, Norwegian Maritime Museum, Oslo; in Sweden: Lars Barkman, *Wasa* Museum, Stockholm, and Carl Olof Cederlund and Bert Westenberg, Statens Sjohistoriska Museum, Stockholm. Although we have not met, I must acknowledge the assistance received via the Internet from Lars Bruzelius, Uppsala University, Sweden, who maintains a very valuable database on nautical and maritime subjects and who quickly responds to requests for information. I met so many people and received so much assistance over the years that I am certain others have inadvertently been omitted.

I want to thank my current employer, the Sanctuaries and Reserves Division of the National Oceanic and Atmospheric Administration (NOAA) for encouragement and for allowing me to schedule personal leave when necessary to complete the research for this thesis. Most of all I offer my love and gratitude to my wife, Sharon, and daughters, Jennifer and April, who patiently and lovingly tolerated my obsession with "old ships." My parents, Dorothy and William Clinton Broadwater, also deserve thanks for their support and encouragement. It is to my father, who never failed to ask me how my thesis was progressing but who did not live to see it completed, that I dedicate this study.

Finally, I want to thank the faculty of the Scottish Institute of Maritime Studies, University of St. Andrews, for their very able and cheerful encouragement, advice and support, particularly Martin Dean, Ian Oxley, Robert G. W. Prescott and especially my advisor, Colin C. J. Martin. Dr. Martin provided valuable advice during the Yorktown Shipwreck Project and was a very supportive and helpful advisor throughout my thesis research. He always offered frank and constructive comments and suggestions along with enthusiastic encouragement. Dr. Martin's mentorship made my academic experience at St. Andrews both mentally rewarding and personally enjoyable.

Shipwrecks from the eighteenth century are being discovered and studied in ever-increasing numbers, thus building a data base for the development of a more accurate picture of these vessels and for incorporating the resulting picture into the developing chronology of wooden ship evolution. I hope this thesis will contribute to that effort. As author I gratefully acknowledge all assistance received, but must assume full responsibility for any errors and omissions. I particularly wish to apologize if I have not done justice to English merchant ships and their builders.

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Abbreviations Used in the Text

Add.Mss.	Additional Manuscripts
ADM	Admiralty
Am.Nept.	*American Neptune*
BM	British Museum
BT	Board of Trade
CO	Colonial Office
EHR	*Economic History Review*
Eur.Mag.	*European Magazine*
HCA	High Courts of Admiralty
IJNA	*International Journal of Nautical Archaeology and Underwater Exploration*
LR	*Lloyd's Register of Shipping*
MM	*Mariner's Mirror*
NMM	National Maritime Museum, Greenwich
NRJ	*Nautical Research Journal*
PRO	Public Record Office
SP	State Papers
TMM	The Mariners' Museum, Virginia
VDHR	Virginia Department of Historic Resources
VSLA	Virginia State Library and Archives
WLPS	Whitby Literary and Philosophical Society

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Introduction

The two principal goals of the present study are to provide a detailed description of eighteenth-century English merchant vessels and to test the hypothesis posed in 1962 by Professor Ralph Davis (1962:71) that during the eighteenth century a significantly improved merchant vessel type emerged in England that required a smaller crew but carried more cargo than previous English vessels, thus boosting England's position as one of the world's greatest maritime nations. A further goal is to develop vessel descriptions that not only will be of use to maritime historians but also will assist nautical archaeologists in identifying and classifying shipwreck remains. Merchant vessels were chosen for study because of the relative scarcity of scholarly publications on commercial vessels from the age of sail and because of the wealth of new archaeological data on English merchant vessels that has emerged during the past two decades.

Throughout the long maritime history of northwest Europe the vast majority of all sailing vessels afloat at any given time were merchant vessels, not warships; they were privately built, relatively small, and employed either in commerce or fishing. In spite of their ubiquitousness, however, surprisingly little is known about merchant vessels built before the nineteenth century. Knowledge of early naval vessels, though itself limited, is by comparison with their contemporaries in the merchant service much fuller because, as Muckelroy (1978:92) noted, "so far as the general run of merchant shipping was concerned, little was recorded until the end of the Age of Sail."

An interesting exception is found among Scandinavian vessels. Basil Greenhill (1976:202) observed that "we know today more about the evolution of the ship within 250 miles of the Skaw between A. D. 800-1200 than about the development of almost any other kind of ships and boats until modern times." His remark was quite justified due primarily to two factors: The Viking practice of burying important persons in ships has provided terrestrial archaeologists with well-preserved specimens of Viking ships, while underwater discoveries such as those in Roskilde Fjord furnished additional archaeological examples of a variety of Norse vessel types (Christensen 1972:166-180; Crumlin-Pedersen 1972:183-201; Greenhill 1976:208-221; Muckelroy 1980:68-75). Reassessing the topic a decade later, Greenhill (1988:45) maintained that the situation had not appreciably improved.

Not only is there a general paucity of data on eighteenth-century merchant ship design and construction, but there is little recorded information on matters such as rigging, interior configuration, stores, equipment, command, social structure or daily life. As a result, even though the world's merchant marine has always greatly outnumbered its naval counterpart, our knowledge of these vessels of commerce is generally lacking. This dearth of information can be attributed to at least two major factors: the unavailability of mathematical and graphical tools for hull design and the inability of most merchant builders to apply nautical architectural theory or even to adequately document the vessels they built.

Efforts to develop mathematical formulae for use in ship design can be traced back to at least the late sixteenth century. It was not until well into the eighteenth century, however, that the complex form of a ship's hull could be fully and accurately defined on paper. Even then, in spite of numerous treatises on the subject, most written in Europe,[1] the instructions presented were often incomplete, in disagreement with each other, and even inaccurate. More significantly the state-of-the-art of ship construction did not permit a vessel to be built exactly according to a model or plan. That problem was exacerbated by the fact that few shipwrights possessed the knowledge to interpret and apply—or, in many cases, even to read—those treatises. While a few theorists promoted the concepts of systematic, rigorous ship design, most shipwrights were content (indeed, for the most part, constrained) to build vessels based on the practical knowledge and skills which had been passed down to them from other shipwrights. According to Unger (1978:42) "most builders ignored the largely impractical theories offered them before 1800 …." As a result, many extant eighteenth-century lines draughts are actually retrospective (i.e., as-built hull form) plans rather than prospective (i.e., design hull form) plans. Consequently, early ship plans are scarce and, as discussed later in this study, a definite lack of standardization among vessel remains has been confirmed by recent archaeological investigations.

Another major difficulty in analyzing naval architecture from this period is that there was no general agreement among shipwrights on the "ideal" hull form or rig for a particular purpose. There existed an even broader diversity of opinion among shipbuilders in merchant yards than in naval yards and there was little incentive to standardize. Surprisingly, until the seventeenth century all vessels were constructed using traditional methods, relying upon time-tested hull forms and rules-of-thumb but few written specifications. Documentation for warships was improved in the seventeenth century when European administrations began to regularize warship development and form, with help from mathematicians who developed the necessary formulae and graphical theories.

At this time a knowledge gap between naval and commercial vessel design began to form, primarily due to the growing differences between the needs and resources of naval versus merchant shipbuilders. Even though the world's navies had increased their efforts to standardize, and consequently to document, their shipbuilding practices, there was no such trend in merchant yards.[2] Consequently, almost all surviving plans and models until well into the eighteenth century are of warships, as are most contemporary data in shipbuilding and rigging treatises. In the seventeenth and early-eighteenth centuries, merchant vessels, even very large ones, were built by "rack of eye"—that is, purely by the knowledge and skill of the builder, without benefit of plans or, frequently, descriptive contracts. When contracts were written they often specified only general configuration and primary dimensions. This discrepancy of construction methodology is emphasized by the standard practice of the Royal Navy of assigning a naval contract officer to closely oversee the construction of naval vessels under contract to merchant yards.

Besides lack of standardization, the gap between naval and commercial vessels is attributable to several additional factors. For one, merchant shipwrights may have deliberately opposed standardization in order to protect the secrets used in constructing their own vessels. Other factors included the relative isolation of many of the merchant yards from the principal naval shipyards, the variation in availability and cost of building materials and labor, and differences in regional and local requirements for vessel size and functional design. In addition, the gap appears to have developed in part as a result of scholarly bias, both then and now, toward the study of larger ships.

The disparity in shipbuilding practice should not be taken as an indication that shipwrights in merchant yards were ignorant or inferior to their counterparts in naval shipyards. In fact many private shipyards, particularly those on the Thames and near naval yards, frequently built ships for the Royal Navy. Therefore, many builders of merchant ships undoubtedly possessed some familiarity with naval shipbuilding standards. Although it is the nature of bureaucracies to insist on detailed documentation and standardization, merchant yards were bound by no such conventions or restrictions. Indeed there was a disincentive for merchant shipbuilders to invest time in generating such documentation, since shipwrights tended to jealously guard their own successful methods in order to maintain a competitive edge.

It seems reasonable to speculate that some English shipwrights, especially in the more remote areas, probably operated with little outside influence, relying instead upon the traditions passed down from local shipwrights and dictated by local preferences, commercial needs and environmental factors. This independent approach was undoubtedly even more typical of builders of small craft. The freedom from restrictions and conventions enjoyed by merchant builders most probably resulted in innovations borrowed from other vessel types and discovered through experimentation with unconventional designs. Since ships were built on or near the coast, in ports that were visited by ships and boats of many types and origins, merchant shipwrights were free to observe and copy those features that they thought desirable. Thus, innovation and change came more rapidly in merchant yards than in the King's yards, and regional variations were far more common.

Another factor limiting the use of plans in merchant yards was the inability of almost all shipbuilders—even as recently as the early nineteenth century—to construct a vessel that exactly matched a given model or set of lines drawings, much less to produce several identical vessels. When the eighteenth century brought a surge of shipbuilding in the ports of northern England, there was apparently no corresponding increase in the use of plans. The recent efforts of numerous researchers have produced little documentary evidence concerning these vessels, probably because they were built from instructions passed down from shipwrights to apprentices.

Scholarly biases are also partly responsible for the lack of published information on post-Medieval merchant ships. Research into merchant vessels and small craft has been limited by a lack of scholarly interest as well as by the dearth of information. During the eighteenth century few historians or naval architects wrote in detail about merchant vessels. Today, maritime historians, archaeologists and salvors are all too frequently attracted to famous or treasure-bearing ships. Just as historical studies often emphasize wealthy persons and famous buildings, so naval and maritime studies tend to focus on important ships-of-the-line, famous naval officers and major sea battles. Few researchers have been sufficiently interested in the technology of shipbuilding to acquire the necessary skills for developing detailed descriptions of the few archaeological examples that have been located. In fact, very few universities can provide such training.

The somewhat pessimistic assessment offered above is partially balanced by the fact that historians, in spite of numerous impediments, have succeeded in building a solid foundation from which to conduct detailed analyses of early merchant ships. Only in recent years has the emphasis in terrestrial and underwater archaeology shifted to more comprehensive studies of the past through investigations of a broad spectrum of social, economic, political and technological factors (Adams 1993:29-31; Bass 1988; Davis 1962; Deetz 1977; Glassie 1968; Gould 1983; MacGregor 1985; Muckelroy 1978; South 1977).

It was Ralph Davis who first examined the English merchant marine in sufficient detail to theorize the relationships between economics, maritime commerce and shipbuilding. In his seminal book, *The Rise of the English Shipping Industry* (1962), Davis offered an extensive, if general, analysis of English merchant sailing vessels. Drawing upon available documentation from the seventeenth and eighteenth centuries, he developed a very compelling and plausible theory of the evolution of English merchant ships during that period. Davis concluded that throughout the seventeenth century Dutch *fluyts*, or flyboats, were the most efficient and cost-effective bulk cargo carriers in Europe. Their box-like hulls provided maximum cargo capacity while their simplified rig permitted a relatively small crew size.

English merchant ships, on the other hand, were not considered to be competitive during the seventeenth century and most English goods were transported in foreign bottoms, frequently those of the Dutch (*Ibid.*:47-9; Unger 1978:113). Davis (1962:53) found evidence of widespread use by English merchants of Dutch vessels captured during the Anglo-Dutch wars between 1652 and 1674. He further concluded that this situation changed dramatically during the first half of the eighteenth century, as evidenced by a striking growth of the shipbuilding industry in the north of England, particularly on the northeast coast. Davis saw this as

> indicating—in the absence of positive evidence—that the north-east coast was the place where sprang to life, in the decades around 1700, the new industry with the future in its hands, the building of English ships which could adequately replace the vanishing Dutch flyboats (*Ibid.*:61-2).

According to Davis the technological improvements of the new north-built vessels consisted of changes which increased cargo capacity and decreased the number of crew required for a vessel of given tonnage. He postulated that the improved English vessels incorporated many qualities of the Dutch flyboats which, after years of service in British commerce, had begun to reach the ends of their useful lives and to require replacement. As Davis stated,

> . . . the main technical development in English shipbuilding of the early eighteenth century was the adoption, for appropriate purposes, of the hull forms used earlier by the Dutch, which made possible a high carrying capacity in relation to the ship's main measurements. This is the explanation of the small crews of English ships in the Northern trades, where great stowage was particularly important (1962:65-6).

Davis (*Ibid.*:71) maintained that available evidence, while admittedly limited, suggested that the "drastic reduction in crew size in the middle decades of the eighteenth century bespeaks a technical advance of some magnitude." Stevens (1949:7) likewise believed that "merchant ship design [underwent] rapid development during the latter half of the 18th century," but he offered no suggestion as to the cause or even the specific improvements to which he was referring.

Modern historians with a more detailed knowledge of wooden sailing ships have, for the most part, found insufficient evidence to support Davis's theory. Parry (1971:215) argued that "the improvement of manning ratios in eighteenth century merchant ships was too big and too continuous to be entirely explained by the modest increases in size and improvements in rig ...." Parry believed that other factors were at work, particularly the increased naval protection for merchant vessels which, he argued, reduced the need for such vessels to carry guns and the extra crewmen to man them.

In 1980 MacGregor published *Merchant Sailing Ships, 1775-1815*, the first detailed examination of late eighteenth century merchant vessels. In this important book, revised in 1985, MacGregor also questioned Davis' theory, arguing that

> ... it is difficult to attribute the reduction in numbers [of crewmen, as discussed by Davis] to any vital changes in the eighteenth century comparable with those that occurred in the nineteenth (1985:14).

MacGregor suggested that the acknowledged decrease in manning levels could instead have resulted from a combination of such factors as reductions in armament due to the convoy system, more efficient equipment such as pumps and windlasses, and improved port labor and facilities.

Contemporary sources do not suggest that there was a radical development in ship design during the eighteenth century. In fact Chapman, in the preface to his widely-respected shipbuilding treatise of 1775, implies the contrary, stating that when the evolution of ships is examined,

> ... we should at first sight be inclined to believe, that the art of ship-building had, at length, been brought to the utmost perfection. An opinion that would receive additional force from

> a consideration of the few essential alterations, which have been introduced either in their form or rigging, during our own age (1820:vii).

Davis readily admitted that his theory concerning the development of a new vessel type was based upon indirect evidence, adding that

> No expert on ship design has ever examined in any detail the ordinary merchant ship of the seventeenth and eighteenth centuries, and, apart from East Indiamen, only the types that developed at the very end of the 1790's are at all well known (1962:71).[3]

Davis (1962:74) not only pointed out the scarcity of information on early merchant vessels, but he also envisaged that the emerging field of underwater archaeology might significantly contribute to the partial bridging of this knowledge gap. Since Davis invoked further research more than three decades ago, new studies, both archival and archaeological, have contributed to our knowledge of merchant ship construction and evolution, from early vessels of the Bronze Age to nineteenth-century ships of iron and steel (Bass 1972, 1988; Greenhill and Morrison 1995; Muckelroy 1980; Throckmorton 1987).

Until the advent in the 1950s of reliable, affordable diving equipment, scholarly access to submerged shipwrecks was virtually impossible. Even with today's advanced technological tools the difficulty in locating shipwrecks in the absence of adequate historical information is considerable. Yet Muckelroy (1978:92) urged that the need for "archaeological evidence remains paramount through to the early nineteenth century." To answer this need, a few archaeologists have begun to conduct specialized historical studies in concert with scientific underwater research. The relatively new field of underwater, or nautical, archaeology has already begun to access the most fundamental source of information on early merchant vessels—the remains of the vessels themselves.[4]

Nautical archaeology is capable of making significant contributions to a better understanding of early ships and nautical technology; however, our current data base is so limited that it is important to heed George Bass's plea for the continuation of "historical particularism," a term that has taken on the negative connotation of gathering facts rather than examining the underlying cultural context. Bass's advice, delivered at a conference on shipwreck anthropology, provided a powerful incentive to the present study:

> ... nautical archaeology desperately needs decades of cataloging and categorizing shipwreck remains, for we have so few comparative data with which to work (Bass 1983:97).

Fortunately, since Bass issued that call to action, nautical archaeologists around the world have located and documented a fascinating variety of boats and ships. Greenhill (Greenhill and Morrison 1995:7), in introducing a revision of his original book on the archaeology of boats, reports significant progress:

> In the twenty years since an earlier version of this book was published in 1976 the study of the archaeology and ethnography of boats and vessels has advanced very greatly. Perhaps more has been done to increase our knowledge than in the whole history of the study of the subject before.

After opening on this optimistic note, however, Greenhill (Ibid.:23) cautions,

> ... the account of the development of the boat available to use at present is still essentially fragmentary and we have as yet little real knowledge of the history of that development. At the end of the twentieth century the subject has been studied and recorded only here and there .... Sometimes chance has brought about the survival of actual remains of ancient boats and their discovery and, sometimes, proper excavation; even more rarely, adequate recording and publication.

Even in light of recent research, therefore, Davis's hypothesis on the evolution of English merchant vessels remains untested. Published historical studies on seventeenth- and eighteenth-century merchant ships are still scarce, and even fewer archaeological reports on shipwrecks from that period have been published. During the present study significant new material has come to light, making possible the development of a more accurate and complete picture of early merchant vessels than has heretofore been available. The inspiration for this study was the discovery and investigation of a group of eighteenth-century shipwrecks at Yorktown, Virginia.

From 1978 to 1990, as senior underwater archaeologist for the Virginia Department of Historic Resources,[5] I directed the investigation of nine British vessels sunk during the 1781 Battle of Yorktown, the last major battle of the American War of Independence. Two are the remains of the warships HMS *Charon* and HMS *Fowey*, while the other seven are transports and victuallers that supplied the British army at Yorktown. Our efforts concentrated primarily on the supply vessels, since little of the two warships survived and because we believed that the transports and victuallers were more likely to yield significant archaeological data of a type unavailable in documentary records.

Data from these wrecks has provided solid evidence of merchant vessel construction and configuration. The complete excavation of Yorktown shipwreck 44YO88, later identified as the *Betsy*, provided a well-preserved example of the north-country collier from the period during which radical improvements were alleged to have occurred. For the present study I drew heavily upon archaeological data from the shipwrecks at Yorktown, as well as from other relevant sites.

As I began conducting background research, I was advised that relatively little information was available on eighteenth-century British merchant vessels. When I visited repositories in the United Kingdom, however, I discovered several very relevant documents, encouraging me to pursue this somewhat neglected field of study. As more material came to light, a much more detailed—though still incomplete—picture of eighteenth-century merchant ships and shipping began to emerge.

This study seeks to identify patterns of change and innovation in merchant vessel evolution in northern England during the eighteenth century, especially that of the famous north-country colliers which were flat-floored and box-like in shape, with bows as "round as an apple ..." (Lubbock 1922:58). Colliers became widely associated with an allegedly new type of full-bodied bulk cargo design being built primarily in northern ports during the eighteenth century. This study is essentially limited to ocean-going English merchant vessels, and excludes larger types such as East Indiamen as well as smaller fishing, coasting and riverine craft. Likewise, vessels from the European continent and North America are not treated in detail.

As stated at the outset, the primary goals of this study were to test theories relating to the emergence of a new and improved English merchant vessel type during the eighteenth century and to generate a detailed description and comparison of English merchant vessels from that period. It was also stated that the vessel descriptions were to be useful to nautical archaeologists in identifying shipwreck remains. The study identifies and quantifies changes in hull form, rig and equipment of English merchant ships from the late seventeenth century to the beginning of the nineteenth century, when naval architecture was beginning to evolve into a more fully documented and regularized form.

A basic strategy for this study—one that reaped a bountiful harvest—was to visit the former shipbuilding centers of northern England in search of data on merchant ships from the heyday of collier-building in the eighteenth century. Some very significant information on Scarborough shipyards and vessels was found in the possession of descendants of the Tindall shipbuilding family, who very graciously made the papers and objects available to me. Of equal importance is a Whitby collection of detailed masting and sparring records from the Smales firm.

Another productive strategy was to examine British Admiralty records for information on merchant ships being employed as transports, victuallers and other auxiliaries. An incredible wealth of information was discovered in these records, especially those of the Navy Board and, to a lesser extent, those of the Treasury Board and the High Courts of Admiralty. Although the lines of merchant ships were rarely drawn in private yards, the lines of those merchant vessels taken into the Transport Service were frequently recorded in Naval dockyards. Admiralty records also contain surveys, descriptions and valuations of merchant vessels being considered for transport duty; some of these descriptions are quite detailed. For balance and completeness, a comprehensive range of sources was utilized, including manuscripts in the Public Record Office and other official repositories, shipping and shipbuilding records in private collections, published contemporary works on naval architecture, surviving plans and models, and—a relatively new source—archaeological data.

In order to analyze data on eighteenth-century merchant vessels, I found it necessary to develop a relatively straightforward and simple means of describing and characterizing those data in a manner which would define key diagnostic attributes and permit effective comparison. In order to minimize the amount of modern bias which inevitably creeps into descriptions of the past, I attempted to apply only vessel terminology that was in use during the period under consideration. (A Glossary is included for reference.) I have confined my analysis primarily to descriptive comparisons which avoid the difficult geometry and mathematics of modern naval architecture, since the available data are inadequate for a more rigorous approach. Although my analyses may seem incomplete or even simplistic, I believe that the vessel attributes which I have defined and described in Chapter 2 are those for which adequate documentation is most likely to be available and are both appropriate and adequate for addressing the questions posed in this study.

I have analyzed and presented the data in two major categories: historical and archaeological. For historical evidence I examined contemporary treatises, shipping registers and port registers, Admiralty records relating to merchant ships in the Transport Service, as well as draughts, models, drawings and paintings. More than a dozen shipwrecks from several countries comprise the archaeological evidence. This study only touches on the prevailing political, economic and technological factors that are likely to have directly influenced the evolution of merchant ships during the eighteenth century and led to the dominance of the northern yards which built them. Those factors have been effectively and eloquently defined by others, particularly Davis (1962) and Nef (1932).

Part I of this study presents an overview of English merchant ships and shipping in the eighteenth century, develops the basic hypotheses and a framework for analysis, then discusses and compares a variety of sources including primary-source documents, early treatises, draughts, models, paintings and drawings. Part II presents detailed archaeological data from the Yorktown shipwrecks, particularly site 44YO88, identified during this study as the *Betsy*, and archaeological data from similar sites. Finally, Part III brings the results and conclusions together by offering a hypothetical general characterization of eighteenth-century merchant vessels.

This study began as post-excavation research for the shipwrecks at Yorktown and rapidly progressed into a much broader synthesis of numerous types of information on merchant vessels from the same time period. As a result, this study presents an accurate, if incomplete, general model of eighteenth-century English merchant vessels and suggests trends in the evolution of these vessels during the century. The vessel descriptions, charts, tables and analyses should also prove immediately useful to nautical archaeologists in attempting to date, classify and identify shipwreck remains. More importantly, this study serves as a baseline for further refinement, through archaeological and historical research, of our knowledge of the development and historical significance of merchant sailing vessels of this crucial period.

Notes on the Introduction

[1] These sources are discussed in detail in Chapter 3 and Appendix B.

[2] Notable exceptions were the East India Companies, which developed their own standards.

[3] Unless otherwise stated, citations for Chapman's works are as follows: For the *Tractat*, information was taken from the 1820 English translation by the Rev. James Inman.

[4] This emerging sub-field of anthropology is variously referred to as underwater, nautical, maritime or even submarine archaeology. This study will ignore the terminology, even though the concentration is on shipwreck remains, normally classified as nautical archaeology.

[5] Formerly the Virginia Historic Landmarks Commission; this agency serves as the state historic preservation office for the Commonwealth of Virginia.

Part I

Documentary Evidence of Eighteenth-Century English Merchant Ships and Shipping

. . . [England's] north-east coast was the place where sprang to life, in the decades around 1700, the new industry with the future in its hands, the building of English ships which ... bespeaks a technical advance of some magnitude.

-- Ralph Davis
The Rise of the English Shipping Industry (1962:71)

Experience would be the best means of perfecting naval architecture, if the thing were possible; but it is plain enough that practice is insufficient in many cases. It is certain, that if this alone is capable of rendering some parts perfect, it has need, in an infinity of others, to be aided by the light of theory.

-- M. Bouguer
Traité du Navire (1747:xviii)

The science of Marine Architecture has, for many ages, been subservient to the impulses of ambition, avarice, luxury, or curiousity: it remained for Britain, in the eighteenth century, to direct it to purposes more truly noble and patriotic, of general benefit, and of universal extent—to the prevention of domestic misery; to the maintenance of national population; and to the preservation of the human species.

-- John Charnock
An History of Marine Architecture (1800:412)

Part I
Documentary Evidence of Eighteenth-Century English Ships and Shipping

Chapter 1 of Part I of this study provides a broad, general background on the evolution and form of eighteenth-century English merchant vessels from which the subsequent detailed discussions and analyses are developed. This chapter draws heavily upon secondary sources, many of which provide significant insight into English merchant vessels and the development and growth of the English merchant marine. Chapter 1 concludes with a more specific description of eighteenth-century merchant vessel hull forms and rigs. Chapter 2 sets the stage for technical analysis of merchant vessels by providing a framework for analysis that includes concepts of modern naval architecture. To facilitate the analysis, I have developed several new descriptive terms that lend themselves more readily to the types of data that are available for eighteenth-century vessels. Chapter 3 briefly outlines, then analyzes, the major eighteenth-century treatises on shipbuilding and other contemporary documents that shed light on the state of naval architecture during that century. Documents utilized in Chapter 3 include, in addition to the treatises, a diverse range of port registers and records, Admiralty records, plans, paintings and models.

Part I, therefore, is a survey and synthesis of primary and secondary written sources on English merchant vessels from the eighteenth century. This synthesis is based on both qualitative and quantitative data and is intended to provide sufficient information for the discussion and analysis of relevant archaeological sites and historical vessels in Parts II and III.

Chapter 1

A Survey of Scholarly Publications on the British Merchant Shipping Industry in the Seventeenth and Eighteenth Centuries

The Beginnings of the English Merchant Marine

The origins of European sailing vessels can be traced to two early shipbuilding traditions: northern and southern. Scandinavia produced round-hulled, clinker-built vessels commonly associated with the Vikings, while flat-bottomed, high-sided, deep-draft vessels, usually with clinker-built sides, were typical of West Germany and the Low Countries (Greenhill 1976:259).

By the fifteenth century these distinct types were beginning to merge into a new vessel type. The resulting vessel incorporated many of the best qualities of both traditions but also introduced important new innovations. Frame-first construction began, to some extent, to replace shell-built hulls and three and four masts with a varied suite of sails became common. Greenhill (1988:75) calls this development "the invention of the sailing ship."[1] He suggests that this new ship

> represents one of mankind's most important technological developments, comparable in its long term effects, and the speed with which they came about, with the development of steam power or electricity (1988:67).

The first full-rigged, three-masted ship may have been built somewhere on the Biscay coast of France around the second quarter of the fifteenth century (Anderson and Anderson

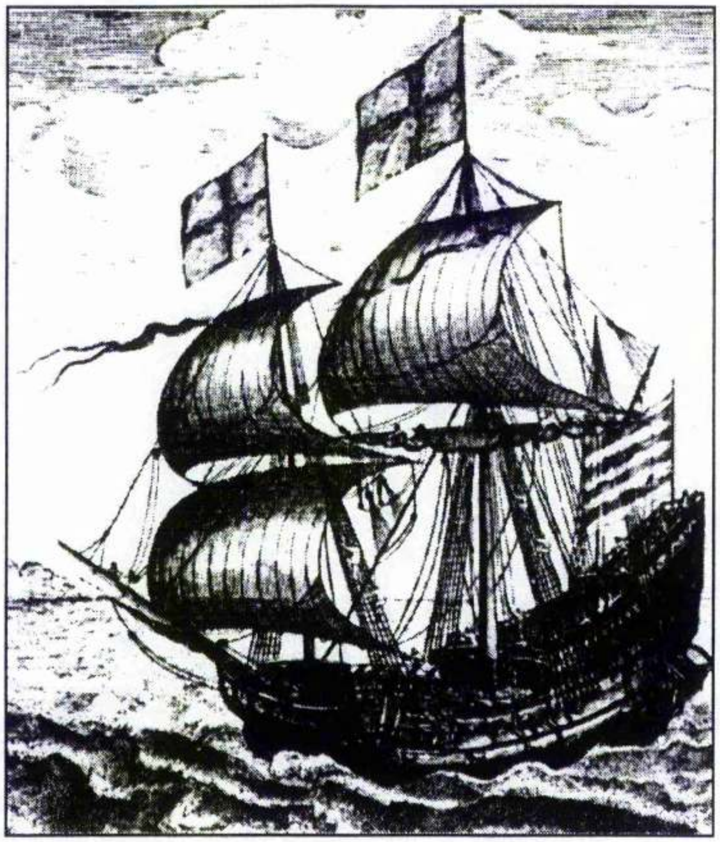


Figure 1.1. Carrack, 16th century (F.H. Breughel)

1963:119; Landström 1961:96; Unger 1978:32); or it may have developed in the western Mediterranean around the middle of the century as an adaptation of the cog (Parry 1981:64). However, recent scholarship indicates that three-masted vessels were in use in England as early as 1420 (Greenhill 1988:75). In any case, by the end of the fifteenth century, two designs had emerged as reliable and efficient vessel types, and these were to predominate, with only gradual modifications, for two centuries: they were the carrack and the caravel.

Carracks were large, full-bodied merchant vessels built on the lines of the older northern cogs. These bulk carriers often exceeded 600 tons in burthen, were heavily built, carvel planked, with high, bulky castles fore and aft (Figure 1.1). They carried a "barque" rig—that is, three masts, square-rigged on fore and main masts, with a fore-and-aft triangular lateen sail on the mizzen mast (Greenhill 1988:68-73; Landström 1961:98-101; Parry 1981:64).[2]

Caravels, at the other end of the scale, were primarily coastal traders, built in the Mediterranean tradition (Figure 1.2). They were usually more lightly built, carvel planked and of 60-70 tons in size. They had a single deck, with no superstructure forward and a low poop aft. Caravels were two- or three-masted, lateen-rigged vessels and sometimes were fitted with square sails for long voyages (Greenhill 1988:74; Landström 1961:106-107; Parry 1981:65). Descriptions and nomenclature from this period are not always precise.

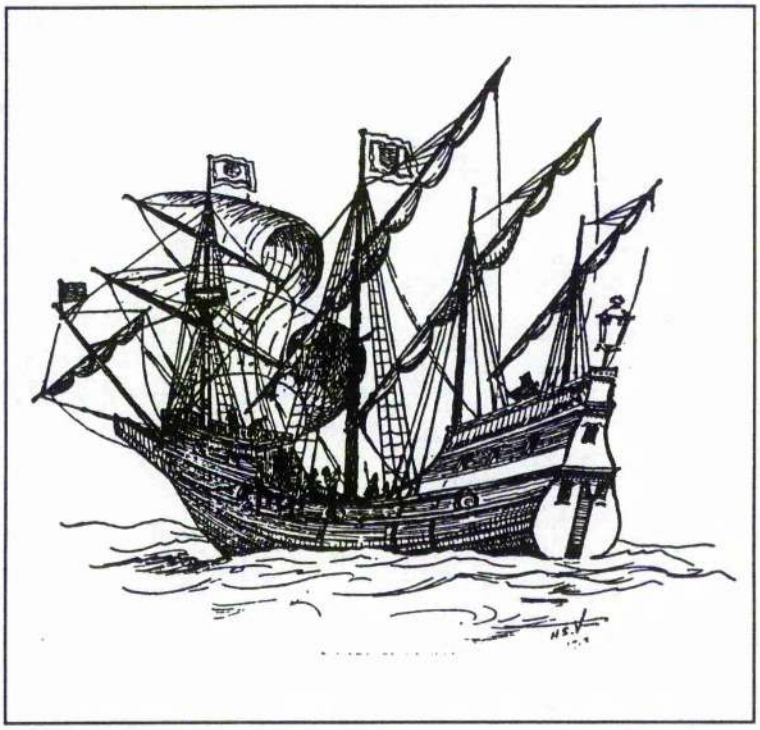


Figure 1.2. Caravel, 16th century (Vaughan 1913:172)

For example, there is still disagreement concerning the nature of Columbus's vessels. At least two were probably caravels for which we have at least some written information. Kemp (1978:67-70) argued that all three of Columbus's vessels in 1492 were a "barque" rig known at the time as *caravela redonda*. Anderson and Anderson (1963:123) insisted that the *Santa Maria* was "an ordinary three-masted ship with spritsail, foresail, mainsail, main topsail, and mizzen." Landström (1961:106) explains the differences in hull form between caravels and carracks and points out that Columbus often refers to *Santa Maria* as *La Nao*, the ship, as opposed to *Las carabelas*, the caravels *Nina* and *Pinta*.[3]

The sixteenth century brought steady improvements in the basic oceangoing vessel design, but without the radical developments of the previous century. Among the improvements were larger vessels with a corresponding increase in the size, number and types of sails, the lengthening of the hull in relation to its beam, strikeable (removable) topmasts and increased use of pulleys in running tackle (Charnock 1800-1802; Davis 1962:44; Parry 1981:67). Parry (1981:66-7) maintained that two improvements in hull design during the sixteenth century proved to be pivotal steps in the evolution of wooden sailing ships: the evolution of the galleon as a specialized warship, and the development of the Dutch *fluyt* as a purpose-built bulk carrier. Scholars are still debating the exact evolutionary paths taken at that point in the ship's development.

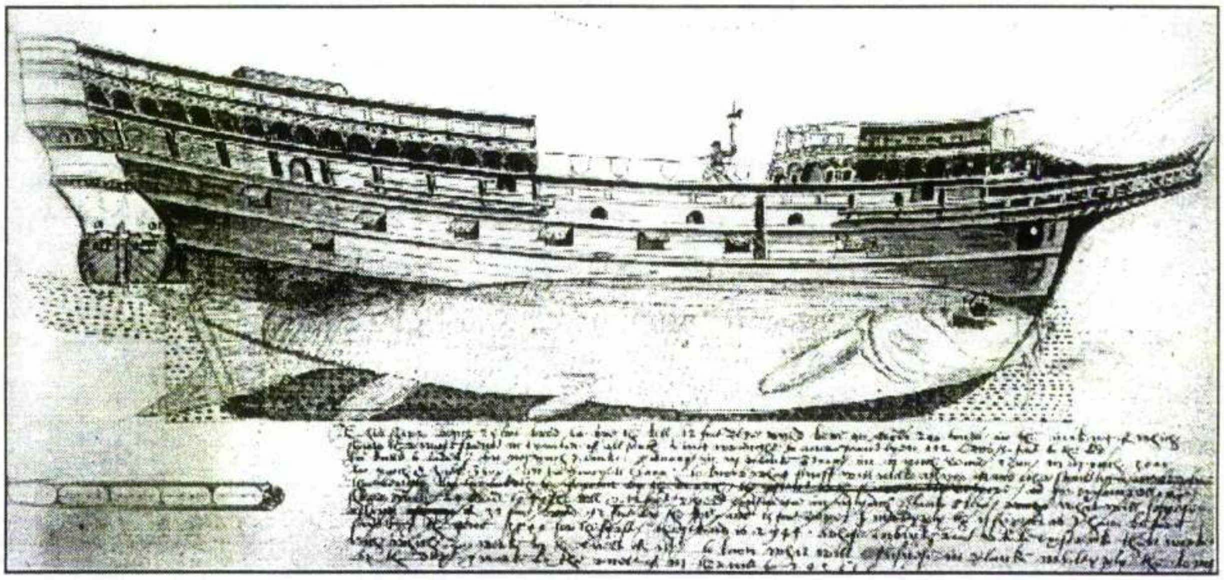


Figure 1.3. Galleon, 16th century (attributed to M. Baker, Pepys Library, Magdalene College, Cambridge).

According to Parry (*Ibid.*:68) Mediterranean shipwrights, building upon their successful and respected galley design, developed a new vessel which was more heavily built, more seaworthy, and reinforced to carry heavy guns. Parry classified the galleon, as it was known, as a specialized fighting ship; it was to be the forerunner of the great ships-of-the-line which were to follow (Figure 1.3). Anderson and Anderson (1963:126) theorized that the galleon quite possibly originated in Spain or Portugal and was a sailing ship, usually four-masted, with "the ordinary ship-rig of the time." The hull, they believed, was built somewhat on the lines of the galley: long in relation to its beam, with lower superstructure and flatter shear than carracks and caravels.

Kemp (1978:96) and Phillips-Birt (1971:204), however, assert that the galleon design was first introduced in England sometime after 1570 and that it was rapidly adopted by other nations. Kemp (1978:93-95) describes the galleon as four-masted, with fore- and mainmasts square-rigged, but mizzen and bonaventure mizzen lateen-rigged; it had a lower profile than previous vessels, a design termed "low-charged." Kemp also states that the term "galleon" was a generic one applied to the new design but which was never widely adopted in England despite its origin there (1978:96). Fincham, in his *History of Naval*

Architecture (1851:36), considered the galleon to be a vessel of Mediterranean origin which evolved from a large, oared galley into a sailing warship with its hull penetrated with gunports. Fincham does not attach the same level of long-term significance to this vessel as do other naval historians. Landström (1961:112-113) conceded that the galleon may have originated in Spain, but that it was found in both Italy and England by the mid-sixteenth century.

The complexity of vessel evolutionary processes is undoubtedly responsible for the confusion regarding galleons as well as other vessel types. By the sixteenth century few coastal areas were completely isolated, and a wide variety of foreign vessel types were at least somewhat familiar to Europeans. Therefore the ship designers and builders of Western Europe were influenced in complex ways which may never be fully reconstructed. It is encouraging to note, however, that current research, especially in light of recent archaeological finds, has begun to answer some questions and fill some gaps in the records.

The Dutch *fluyt*, or flyboat, which appeared around 1595, was an improved development at the opposite end of the nautical spectrum from the galleon (Figure 1.4). The *fluyt* was designed as a "floating hold," and was extremely box-like, with a nearly flat bottom, little rake to stem and stern posts, and a length of four to six times that of the beam. (The high length-to-breadth ratio and tumblehome were designed to minimize customs duties by decreasing the measured breadth from which tonnage was calculated). *Fluyts* were generally three-masted, with fore and main masts stepped well apart to permit a large main hatch for unrestricted access to the hold. The Dutch were pioneers in the development of a simple rig, augmented by labor-saving winches and tackles, which

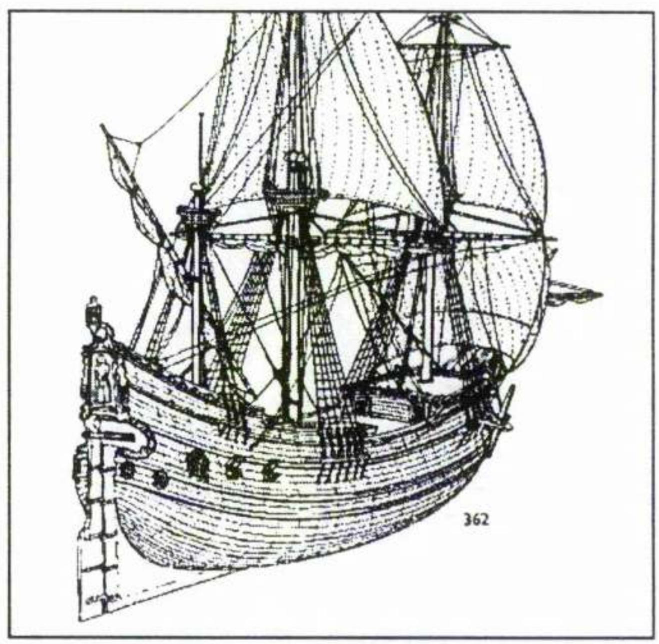


Figure 1.4. Dutch fluyt, *or flyboat, 16th century (B. Landström 1961:Figure 362)*

kept crew and operating costs to a minimum (Landström 1961:154-155; Parry 1981:81; Unger 1978:37). Davis said of the Dutch *fluyt* (flyboat),

> Just what features enabled the flyboat to sail with little more than half the crew carried by comparable English ships in similar conditions is a nice technical question that has not been systematically discussed either by contemporaries or by modern historians of sailing ships (1962:49).

The *fluyt* embodied what most Europeans came to acknowledge as the best qualities that could be built into a bulk-cargo carrier. It seems likely that this efficient commercial Dutch design spearheaded the proliferation of the new and improved English merchant vessels which are the subject of this study. Although the *fluyt* now seems to stand out as a revolutionary new vessel type, it was viewed by contemporaries as the culmination of a long period of improvement in Dutch ship design rather than a radical departure from tradition (Unger 1978:36).

Early sixteenth-century English sea commerce seems to have consisted primarily of coastal trade and local fishing, with the bulk of northwestern European shipping dominated by the Dutch. The second half of the century, however, saw a gradual but significant increase in English shipping. In 1560, the English merchant marine was in its infancy, consisting of perhaps only 50,000 tons of merchant shipping, counting all types of vessels. Although by 1588 England's navy had been sufficiently strengthened to defeat the Spanish Armada, English merchant shipping was, by European standards, insignificant (Davis 1962:2). However, Davis determined that the total size of the English fleet increased dramatically at the end of the century, as can be seen from the following statistics:

Table 1.1
English Merchant Marine, 1572-1629
(from Davis 1962:7)

Date	Total Tonnage	Number of Vessels: 100-199 tons	Number of Vessels: 200 tons and up
1572	50,000	72	14
1577	?	120	15
1582	67,000	155	18
1629	115,000	178+	145+

Unfortunately no surveys are known to have been made between 1582 and 1629, but it is apparent that the beginning of the seventeenth century heralded a new era in English shipping, especially in the number of large vessels employed in commerce. History suggests that this expansion was a response to economic and political stimuli rather than to technological innovations.

Beginning about the middle of the sixteenth century, two of England's shipping enterprises, the fishing and coal trades, began an expansion which was to have a profound effect on her merchant marine for two centuries. Of particular relevance to this study is the rapid growth of the coal trade, which is thought to be primarily responsible for the revolution in merchant shipbuilding in England during the following century (*Ibid.*:4).

English Shipping and Shipbuilding in the Seventeenth Century

The paucity of shipping records from the sixteenth and seventeenth centuries makes it difficult to characterize the quantity and nature of English merchant ships; however, some useful estimates have been generated. At the beginning of the seventeenth century fully two-thirds of all English seamen were employed in the fish and coal trades, both of which required only small vessels. By that time English trade had begun expanding to routes involving longer journeys, especially to Mediterranean and African ports (Davis 1962:4-6). Exploration and colonization were luring vessels on longer open-ocean voyages. In spite of new routes, however, when Queen Elizabeth died in 1603 England's foreign trade was still modest and no overseas colonies had been established (Hope 1990:168).

Determining the volume of shipping and nature of the vessels involved during this period is difficult. Trinity House records indicate that of 159 English ships built between 1626 and 1637, the average size was 217 tons (Davis 1962:55). This figure is misleading for at least two reasons. First, tonnage was computed by several different methods during the 200-year period under study, becoming standardized on a widespread basis only during the eighteenth century. Therefore, tonnage figures cannot easily be compared, either over time or region.[4] In addition, most shipping records do not incorporate the many smaller vessels built in private shipyards that would have appreciably lowered average tonnage values. The *Cadiz Merchant*, 280 tons, shown in Figure 1.5 from an illustration in *Barlow's Journal* (1682:II:328), is a good example of a late seventeenth-century merchant ship. The *Cadiz Merchant* was built in Newcastle, the northeast port destined to become a major center for the production of colliers in the following century.

As a result of the First Dutch War, 1652-4, England acquired a very large number of Dutch prize vessels—at least 1,000 ships—which very possibly doubled the total tonnage of the English merchant fleet. These Dutch ships altered the character of the English fleet, making it more diversified and better-balanced. British vessels had been built for strength, maneuverability and defensibility, and were expensive; the Dutch built high-capacity, shallow-draft vessels which were inexpensive to construct and efficient to sail with small crews. The resulting intimate familiarity which English merchants and shipbuilders gained with Dutch cargo carriers very probably led to a permanent alteration in the character of English ships (Davis 1962:12-13, 51; Nef 1932:174).

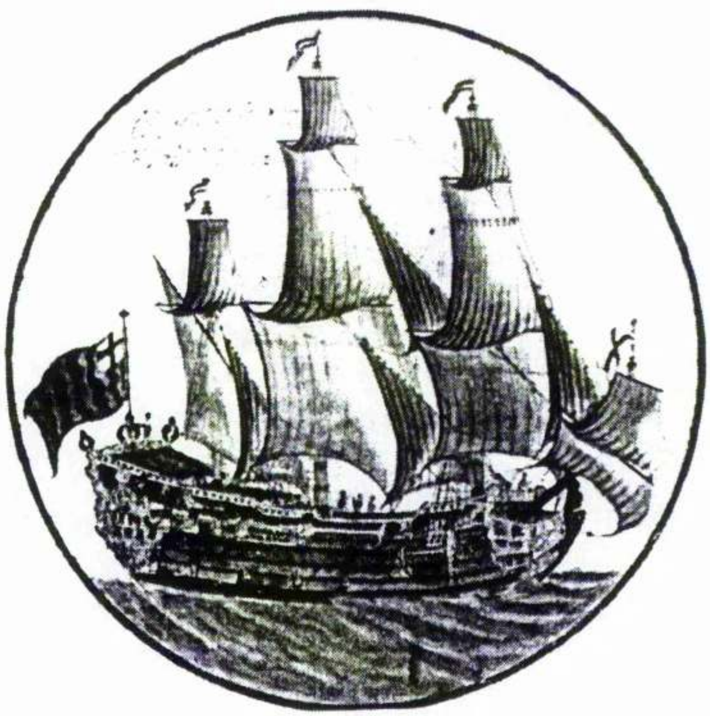


Figure 1.5. English merchant vessel, late 17th century (Barlow 1682:II:328)

English shipbuilding in the early seventeenth century was concentrated in the Thames and in East Anglia. Shipbuilding declined in the latter half of the century, largely because of the ready availability of Dutch prize vessels which satisfied the need for merchant tonnage, and because the rapid growth of the coal trade had moderated. Although larger vessels continued to be built for the East India Company and other firms, many smaller yards found little demand for new vessels (Davis 1962:13). Despite the downward trends in shipbuilding, there were increases in the New World trades of tobacco, sugar and timber, which required relatively large oceangoing vessels, and the Baltic timber trade which was growing due to the worsening timber shortage in England. (*Ibid.*:16,19). In fact, the century from 1582 to 1686 saw the tonnage of the English merchant marine increase fivefold while the population perhaps doubled. Shipping during this period became the fourth largest industry in England, behind only agriculture, cloth-making and building (Hope 1990:201).

Even during the latter half of the seventeenth century, particularly from the 1660s to the 1680s, there was apparently a nearly total dependence upon Dutch ships for the efficient transport of bulk cargos. This preference for Dutch vessels was expressed by English merchants who registered frequent complaints about English ships. The English had, since the mid-sixteenth century, built stout ships mounting cannon for defense and employing a large sail area for speed. These characteristics demanded a large crew in proportion to tonnage, especially compared to Dutch vessels which carried a smaller "proportion of men [and] victual ... near, or answerable to English shipping of the same Burthen" (from *The Advocate*, 1651, quoted in Davis 1962:50). The conspicuous lack of such complaints after 1700 strongly suggests that by the beginning of the eighteenth century English shipyards had begun to respond by building more satisfactory, possibly Dutch-like, merchant vessels (Davis 1962:53-4). Certainly, before the end of the seventeenth century Anthony Deane and Phineas Pett had begun to apply scientific principles to English shipbuilding, paralleling similar activities in Europe (Cornewell-Jones 1898:62-3; Fincham 1851:xiii).

English Shipping and Shipbuilding in the Eighteenth Century

The eighteenth century saw a dramatic increase in English shipbuilding as well as a shift to northern yards. This period also produced a more-or-less standard range of hull and rig types that endured for another century, a fact that is discussed below in much more detail. The English merchant fleet grew more rapidly than any in Europe, tripling in total tonnage during the eighteenth century (Parry 1971:205). Davis (1962:22) effectively presented data verifying that this period of growth occurred only after half a century of stagnation beginning in 1689. Davis (1962:61.2) hypothesized that the increased production of English vessels was due, at least in part, to the fact that captured Dutch vessels, placed into the English merchant marine in the seventeenth century, were wearing out and required replacement.

In 1786 compulsory ship registration was instituted in Great Britain, resulting in the recording of much more complete data on merchant vessels. At that time, nearly all registered vessels were smaller than 200 tons burden. Of 9,355 vessels owned in English ports in that year, fully 7,756 (83%) were under 200 tons. Of the 1,156 ships built in England during 1790-91, all but 150 (87%) were under 200 tons, with the average tonnage being 90. During this period, a majority of vessels in the under-200-ton range were two-masted vessels: brigs, brigantines, snows or schooners (*Ibid.*:70,79). According to Parry (1971:207) "it was in a small but growing class of medium-sized merchantmen, from, say, 150 to 450 tons, that the main innovations in design, construction and rig were made, in the first three-quarters of the eighteenth century."

Davis, too, concluded that the beginning of the eighteenth century was a transitional period in English merchant shipbuilding. He states emphatically, "the conclusion is inescapable that by the last decades of the seventeenth century English shipwrights had started to build their own version of the cheaply operated ship [adapted from the Dutch design] and that they were turning it out in large numbers during the long period of peace whose centre is 1726" (Davis 1962:61).

It was during this period that northern yards began to produce the legendary bulk carriers that would soon become known as "north-country colliers." Unfortunately, as Davis (*Ibid.*:61) points out, "there is no direct evidence about shipbuilding in the critical period, from about 1690 to 1720, when the flyboats [Dutch prizes] were wearing out and the English were compelled to build their own coal, timber and flax carriers." Almost two decades later Hope (1990:204-220) could lend almost no new information on this period.

From available data, however, Davis (1962.:61.2) concluded that four things were certain: that shipbuilding on the northeast coast was of small importance throughout the seventeenth century; that by the early eighteenth century large numbers of vessels were being built somewhere in England for great stowage and cheap operation; that by the middle of the century Whitby and Scarborough vessels had a reputation for those qualities; and that by 1787 the northeast coast had become the center of the English shipbuilding industry, "and had obviously been so for a very long time."

Nef, in his definitive two-volume history of the British coal trade, states that by the time of the Restoration nearly all of the old English merchantmen had been superseded (at least in the Newcastle-to-London coal trade) by a "new type of vessel especially designed for the transport of coal." He defined this new vessel type as follows:

> the ideal 'collier' had to be wide and heavy of keel, and so built as to hold the maximum quantity of coal and to be navigated with the minimum number of seamen (1932:390).

That the building of British merchant vessels shifted from the Thames and East Anglia to the northern ports during the eighteenth century is evident from the records; the reasons for this shift are less certain. Nef asserts,

> There is no doubt that it was the expansion of the coal industry in the seventeenth century which led to the changes in shipbuilding which increased hold space and reduced the number of seamen (*Ibid.*:319, n. 3).

Although Nef's statement seems reasonable, it does not explain why the larger and more established shipyards in the Thames, East Anglia and elsewhere did not take the initiative in this new enterprise. Davis (1962:57,61) answered that East Anglia shipbuilders never recovered from the influx of Dutch prizes, while London was fully employed in constructing large ships for the East and West Indies and Levant trades. Possibly London-area builders found these markets to be more profitable and better suited to their building skills and preferences.

English Shipping at the Outset of the American War of Independence

By the outbreak of the American War of Independence the British merchant marine was second to none. It has been estimated that in 1775 approximately 7,700 ships comprising some 608,000 tons were engaged in maritime commerce under English ownership. In that year, nearly 300,000 tons of shipping were engaged in the three most important foreign trades: America and the East and West Indies (*Ibid.*:27,41).

It is instructive to compare these figures to those for the warships in the Royal Navy at that time. In 1778 the Royal Navy consisted of 416 ships, including both warships and auxiliaries, of which only 270 were ships-of-the-line (Montaine 1778:24). By January 1, 1781, undoubtedly as a result of wartime demands, Royal Navy strength had increased to 538 vessels, of which 329 were ships-of-the-line (PRO, ADM 7/567:29). These statistics indicate that at the time of the American War there were approximately 14-18 times as many British merchant vessels as warships.

Not all of these vessels, however, were built in England. Several estimates agree that by 1774 approximately one-third of all British-owned merchant ships were actually built in the American colonies. Champion (1784:21) places the number of American-built vessels at 2,342 of 7,694 (30%). There was disagreement as to the quality of American-built vessels, but few questioned the economic advantage. A British merchant could have a ship built in the American colonies for one-third to one-half the cost of the same vessel in England—a total cost of three to four pounds sterling per ton for a Colonial vessel compared to five to seven pounds for a British one (Fairburn 1945:I:295; Goldenberg 1976:95; Hutchins 1969:153).

Most American-built vessels were constructed by British shipwrights who had relocated to the Colonies, or by Colonial shipbuilders trained by British shipwrights. Therefore it seems reasonable to assume that most of these "Plantation-built" vessels, as they were often described, were built to proportions identical to or very similar to those built in Great Britain.

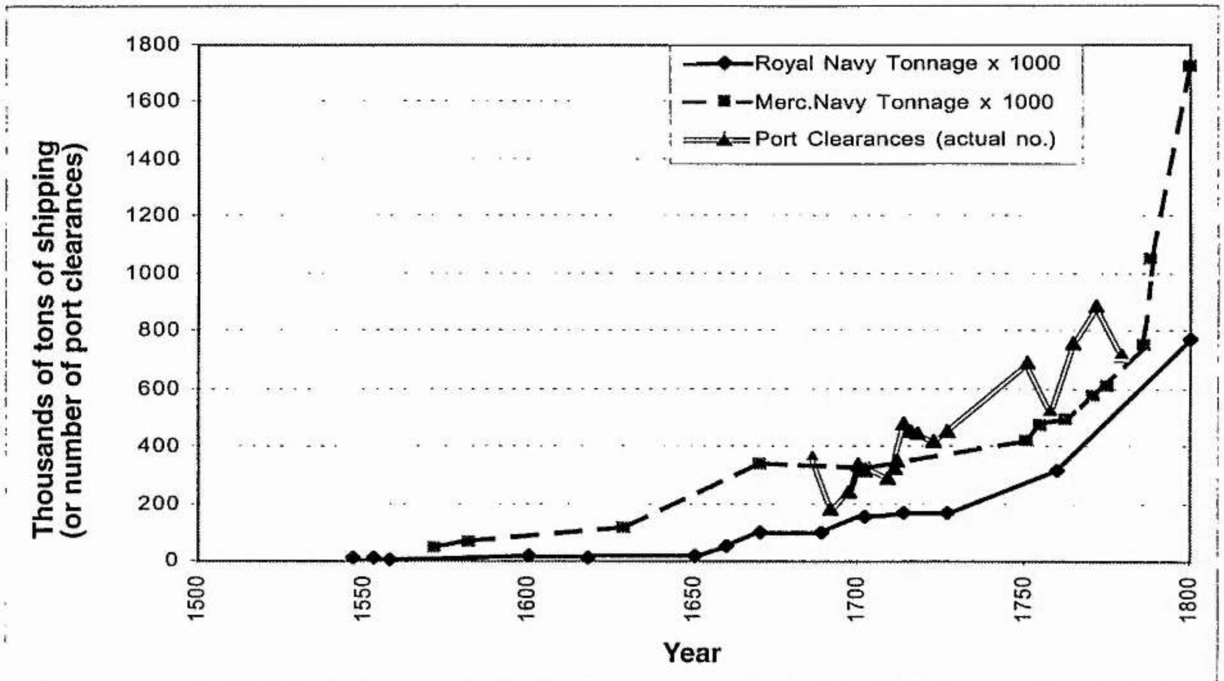


Figure 1.6. Trends in English tonnage and port clearances (derived from Davis 1962:25,27; Fincham 1851:213-14)

A General Characterization of English Ships and Shipbuilding in the Eighteenth Century

The forgoing discussion offers a very brief and general history of merchant shipping and shipbuilding in the seventeenth and eighteenth centuries. No accurate statistics are available on numbers and sizes of ships built in England until nearly the end of the eighteenth century. However, data gathered and tabulated by Davis (1962) and others provide a valuable estimate of the size of the English merchant marine and, by inference, the numbers and origins of the vessels themselves. Figure 1.6 compares the growth of tonnage of English-owned shipping to the number of port clearances from major English ports for the two-century period between 1582 and 1788. For comparison the reported tonnage of warships and auxiliaries of the Royal Navy is also plotted for the same period. Interestingly, both the merchant and naval curves clearly illustrate Davis' reported stagnation period in the first half of the eighteenth century. Growth of merchant shipping continued to be slow in the third quarter. The rapid increase in shipping near the end of the century is dramatically evident.

Also evident in the following graphs is the shift during the eighteenth century of ownership of the English merchant marine from London to the outports, that is, the major ports other than London (See Figure 1.10 for locations of principal ports). All sources suggest that London continued to build and manage large vessels for the Indies and Levant trades while the outports, particularly in the northeast, built and operated increasingly large numbers of bulk carriers of moderate size for the coastal, Irish and Baltic trades. The growth trend in the northeast ports is once again evident in the pie charts (Figures 1.7 and 1.8).

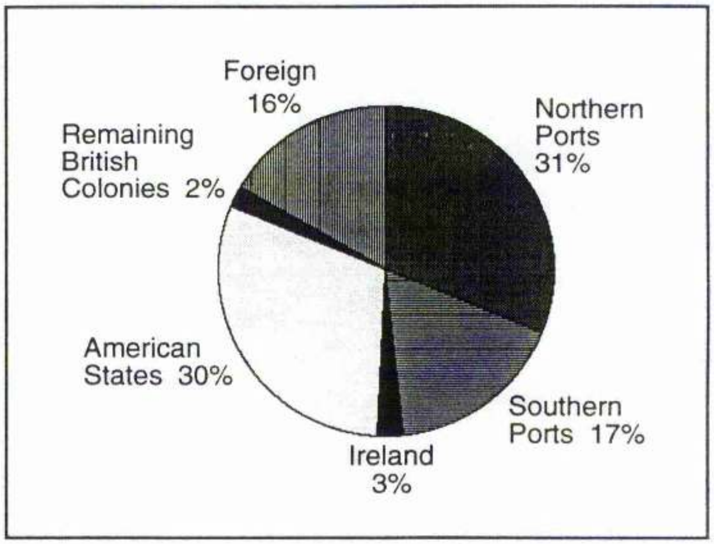


Figure 1.7. English vessel ownership in various regions in 1775-76 (from Champion 1784:21)

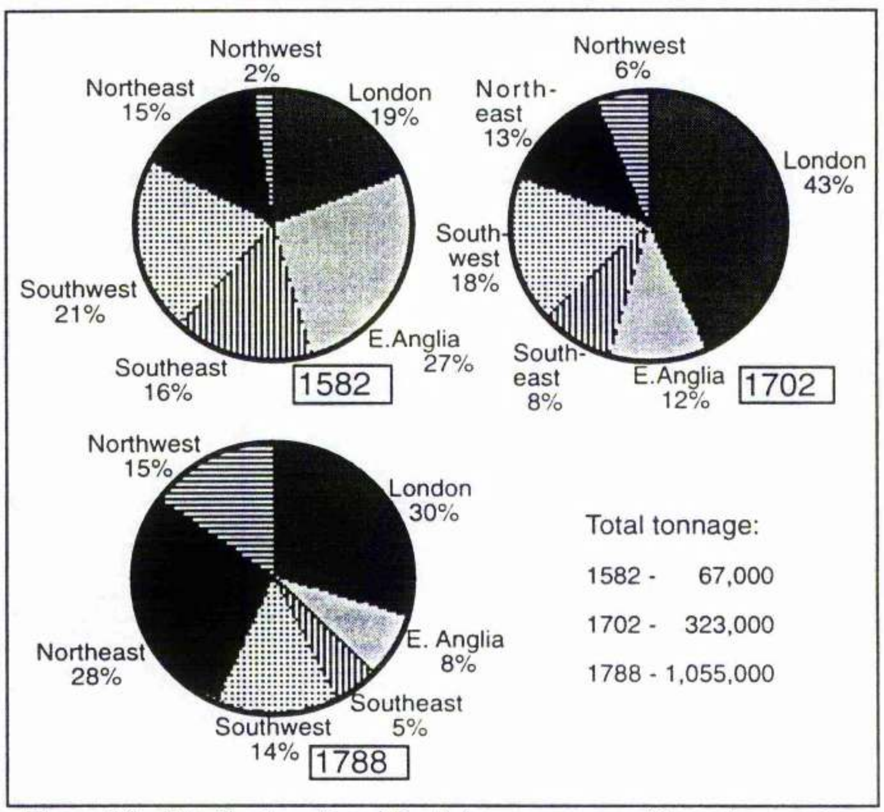


Figure 1.8. Distribution of total English tonnage owned in various regions in the two-century period between 1582 and 1788 (from Davis 1962:33)

From port register books for the years 1775-1776 Richard Champion (1784:21) determined that at the commencement of the American War the merchant marine of Great Britain consisted of 7,694 ships with a total burthen of approximately 1,300,000 tons. Figure 1.7 indicates the sources of those vessels. The shipyards of the American colonies and of northern England provided almost two-thirds of all ships in the English merchant fleet at this time.

Figure 1.8 illustrates the distribution, given in percentages of total English-owned shipping by region in 1582, 1702 and 1788. The shift of ownership from the Thames to the north of England during the eighteenth century is clearly evident, with the biggest losers being East Anglia and the southeast ports as evidenced by the drop in market share from 43% in 1588 to only 13% in 1788. London's overseas shipping interests, particularly the

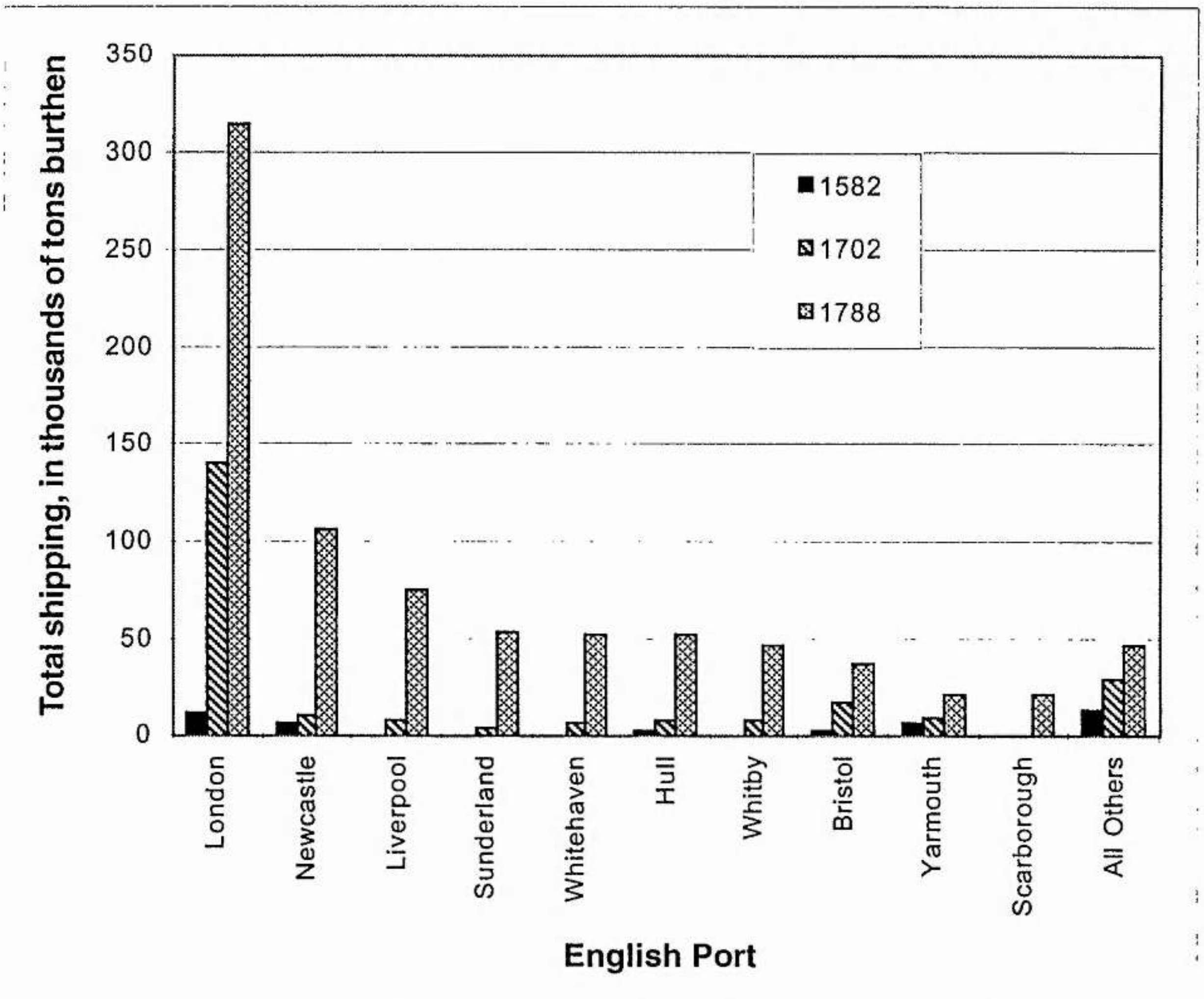


Figure 1.9. Tonnage of shipping owned in the ten leading 18th-century English ports (from Davis 1962:35)

British East India Company, maintained a sizeable market share for that port. In general terms the trend in ship ownership also reflects the shift in shipbuilding to the outports, particularly in the northeast.

Figure 1.9 compares English-owned shipping tonnage for 1582, 1702 and 1788 in the ten leading ports. The figure for London in 1788 is somewhat misleading in that the average size of vessels registered in London in the late 18th century was very small; however, the fact that most of the large East and West Indies ships retained their London ownership kept the total tonnage high for the port of London. The shift in ownership to the northern ports is, nevertheless, quite evident.

Table 1.2 lists the number of vessels built in the twelve leading English ports during the two-year period 1790-1791, with the totals broken down by tonnage ranges (See Figure 1.10 for port locations). It can be seen that London still produced the highest total tonnage, but with the bulk of the remaining tonnage coming from the ports of the northeast. It is also evident that most of the vessels built in all ports were under 200 tons in burthen.

This brief summary of the British merchant shipping industry during the seventeenth and eighteenth centuries provides a framework from which to further characterize the vessels themselves. The sizes and types of vessels registered in major English ports at the end of the eighteenth century are analyzed in more detail below.

English Shipbuilding Theory and Design in the Seventeenth and Eighteenth Centuries

Fincham (1851:xlii) stated that mathematical theories on shipbuilding were virtually unknown in England until late in the eighteenth century; however, it must be acknowledged that even by the late sixteenth century English shipwrights followed a set of widely-accepted design principles as described by Baker (c. 1585), Harriot (1608), Bushnell (1664), Deane (1670) and others. The design principles applied by shipwrights before the late eighteenth century were based almost wholly upon tradition, augmented by observation of the

Table 1.2

VESSELS BUILT IN VARIOUS ENGLISH PORTS, 1790-1791

(From Jones 1982:54, Table 4b)

Place Built	Under 100 Tons	100-200 Tons	Above 200 Tons	Total No.	Total Tonnage
London	84	10	25	119	16,372
Newcastle	10	16	33	59	12,444
Whitby	6	12	31	49	11,754
Hull	48	23	11	82	8,193
Liverpool	26	23	10	59	6,710
Sunderland	4	14	6	24	3,951
Whitehaven	10	16	5	31	3,630
Bristol	21	1	9	31	3,071
Plymouth	37	4	1	42	2,400
Beaumaris	38	3	1	42	1,782
Chester	11	4	1	16	1,488
Lancaster	14	2	1	17	1,323

performance of completed ships. Even Chapman's treatise of 1775 described existing vessels and presented mathematical design parameters based on observation and experimentation rather than a theoretical foundation. In fairness to these pioneers of naval architecture it must be admitted that even today's naval architects—equipped with new theories, advanced mathematics and computers—are still striving for the perfect hull design.

In spite of the dearth of specific information, a few general assumptions can be made about ship design during the period under study. By the early seventeenth century English ships had attained a very "modern" form; that is, the majority of both warships and merchant vessels exhibited certain basic and common characteristics that endured through-

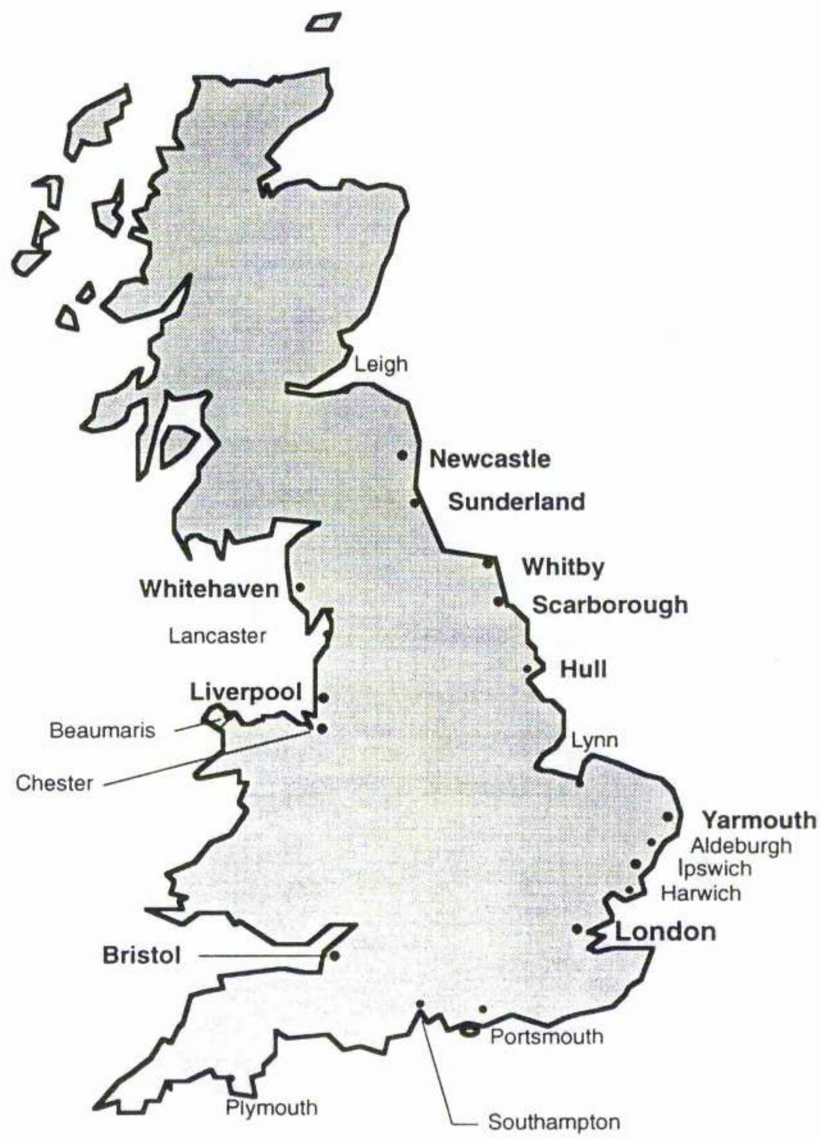


Figure 1.10. Map of England indicating major ports, the ten leading eighteenth-century ports highlighted by bold typeface. (John D. Broadwater)

out the 1600s. Those included a hull form that was wide in proportion to its length; relatively high sides with significant tumblehome; prominent superstructure, or "castles," at bow and stern; three masts, square rigged on the fore- and mainmast, with a lateen sail on the after, or mizzenmast (Davis 1962; Lavery 1988; Parry 1971; Unger 1978).

George Waymouth observed in 1610 that English shipwrights built ships "onely by uncertayn traditionall Precepts, and by Deceiving Ayme of theyre Eye" (BM Harleian MSS:309-368). It is evident that no underlying theoretical basis for ship design existed in England or, for that matter, anywhere in Europe in the early seventeenth century. By this time English shipwrights in London and other shipbuilding areas had formed guilds which basically served to promulgate these traditional methods through apprenticeship training (Davis 1962:54), but also promoted wider acceptance and usage of successful designs.

Just before 1600 the Dutch began building a very efficient bulk cargo carrier known as a *fluyt*, or flyboat. The flyboat had a longer keel-to-beam ratio than former types, a relatively flat bottom, bluff bows, relatively little stem and stern rake and a simple rig; taken together, the flyboat's characteristics permitted it to carry a large cargo with a correspondingly small crew. As a result, the Dutch soon began to dominate the carrying trades of Europe (Davis 1962:48-50; Unger 1978:37). Radical though it may have appeared, the flyboat apparently evolved from previous vessel types to meet specific shipping needs rather than as a result of theoretical innovations (Unger 1978:26,36). As a result of the Dutch Wars of the seventeenth century England acquired hundreds of flyboats as prizes of war, thus depressing the English shipbuilding industry by saturating the market with efficient, cheap Dutch ships and, possibly, forcing English shipwrights to adopt certain features of the flyboat in order to remain competitive. Although most scholars acknowledge the importance of Dutch prizes to the English merchant marine, there is disagreement on the extent to which English shipbuilding was influenced.

By the beginning of the eighteenth century, according to Davis (1962:61), English ships began to reveal Dutch influence:

> The conclusion is inescapable that by the last decades of the seventeenth century English shipwrights had started to build their own version of the cheaply operated [Dutch] ship, and that they were turning it out in large numbers during the long period of peace whose centre is 1726.

Davis (*Ibid*.:62) postulated that the new English merchant ships were a response to the need for a vessel that could adequately replace the captured Dutch flyboats, which were rapidly wearing out. Assuming that this is so—and it seems a reasonable assumption—then it can also be concluded that eighteenth-century merchant ship design, as in previous centuries lacking an underlying theoretical foundation, involved copying and modifying existing vessels. Therefore, it can be concluded that throughout the seventeenth and eighteenth centuries ship design evolved through a system of traditional methods modified, as necessary, by the adoption of or adaptation from alternate vessel types which proved capable of filling a particular need.

From the above discussion it is clear that one can not look to the theoretical treatises of the period for answers to specific questions on the emergence of new vessel types; however, the treatises provide a detailed account of the state of ship design and shipbuilding which must form the foundation for a more in-depth study. Chapman, in his *Treatise on Shipbuilding* (1775:xii), specifies the criteria he deems necessary for design of a proper merchant ship as follows:

> A merchant ship ought:
>
> 1. To be able to carry a great lading in proportion to its size,
> 2. To sail well by the wind, in order to beat easily off a coast where it may be embayed, and also to come about well in a hollow sea,
> 3. To work with a crew small in number in proportion to its cargo, and
> 4. To be able to sail with a small quantity of ballast.

He then discusses the difficulties in satisfying all these criteria simultaneously, summarizing that:

> ... we can conclude nothing concerning the length, breadth, and depth of ships, since different qualities require conditions diametrically opposed to each other .... Wherefore, for a

> merchant ship, it is necessary to combine these qualities, so that it may have the most possible of each (1775:84).

Chapman then offers mathematical formulae for relating these various qualities, establishing what modern designers might describe as "trade-offs" among variables.

The Shipbuilder's Repository (Anonymous 1788:41) lists the following criteria for ship design:

> All ships should have good speed; steer well; feel the least motion of her helm; be "duly poised," or not pitch hard; carry a good press of sail; and sail well before the wind, large, and also keep a good wind close-hauled, without falling off too far leeward. Also, a merchant ship should be able to stow a good cargo. These factors must all be balanced.

Steel (1805:123) states that the four primary qualities of all ships are strength, capacity, stability and swiftness. Other contemporary treatises offer similar design criteria, and one can find similar considerations discussed in modern texts on naval architecture.

Eighteenth-Century Merchant Vessel Classification

No single "generic" merchant vessel type could possibly have satisfied the demands of the wide range of English coastal, transoceanic and fishing trades; consequently, a rich diversity of merchant vessels developed, and these were often grouped into "classes." Contemporary treatises and other nautical documents refer to different types of merchant vessels, but in an inconsistent and often vague manner. The following discussion is based on the best information gleaned from all sources.

Classification by Hull Form

Until the late eighteenth century sailing vessels were generally described or classified in terms of hull form rather than rig. Wherever possible the present study utilizes contemporary terminology and classifications in order for the analysis to be meaningful and accurate. There is no better single source of information on hull types than the collection of ships' plans contained in Fredrik Henrik af Chapman's *Architectura Navalis Merca-*

toria (1768). This remarkable work is a compendium of sixty-four large engraved plates of ships and boats of all types, sizes and origins. Many of the plates contain intricate details of construction and deck furniture. Also included is a plate illustrating twenty-four types of rig. The majority of the magnificent draughts are of merchant vessels, which Chapman groups into five classes:[5]

First class:	frigate
Second class:	hagboat (heckboat)
Third class:	pink
Fourth class:	cat
Fifth class:	bark

For each class, Chapman produced plans illustrating vessels of various size and rig. He also included vessels of small draught of water, vessels for swift sailing and rowing, privateers, and miscellaneous types from various nations. Figure 1.11 is a example of Chapman's skill as a draughtsman and naval architect. From Chapman's plans, MacGregor (1985:29) developed a very helpful table of general characteristics for each major vessel type, adding a sixth type represented in Chapman's plans, the flyboat. MacGregor's table, included here as Table 1.3, is referenced in the following chapter.

Although most of Chapman's plans are thought to be primarily of English vessels, his classification of hull forms was by no means universally adopted by English shipwrights and authors. *The Shipbuilder's Repository* (Anonymous 1788:116-122) classifies merchant vessls by size (tonnage) rather than hull shape, as follows:

First Class	700-800+ tons
Second Class	500-650 tons
Third Class	300-450 tons
Fourth Class	100-250 tons

Other contemporary treatises tend to refer to merchant vessels according to size in tons, burthen, while sometimes also referring to them as ships, barks, brigs, etc., with mixed reference to hull form and rig. Interestingly, the 1797 edition of the *Encyclopaedia Britannica*, which contains an extensive and comprehensive section on shipbuilding (1797:Book I:373-374), makes no mention of vessel types, other than differentiation by rig. Hedderwick, in

Table 1.3

CLASSIFICATION OF EIGHTEENTH-CENTURY MERCHANT VESSELS BY TYPE OF HULL

(From table by MacGregor,1985:29 based on Chapman, 1768)

CLASS	MAX.[6] SIZE	BOWS	STERN	MIDSHIP SECTION	WATERLINES IN HALF-BREADTH
FRIGATE	160' 1275 T	Full head Figurehead, Cheeks, rails	Square tuck Wales go to wing transom or tuck Quarter galleries	Deadrise varies from large to small Round sides Slack bilges	Moderately fine
PINK ⇕	110' 434 T	Full head Figurehead Cheeks, rails	Round stern Wales go to sternpost Square taffrail or narrow lute	Large deadrise Round sides Slack bilges Hollow garboards	Fine entrance and run
HAGBOAT (Heckboat)	156' 1158 T	Full head Figurehead Cheeks, rails	Round stern Wales go to sternpost Square taffrail Quarter galleries	Small deadrise Vertical sides	Moderately fine entrance and run
BARK ⇕	151' 1249 T	Plain stem, no head	Square tuck Wales go to wing transom or tuck	Flat floors (no deadrise) Hard bilges Vertical sides	Full entrance and run
CAT	153' 1120 T	Plain stem, no head	Round stern (narrow) Wales go to sternpost Square taffrail	Small deadrise Vertical sides	Full entrance Finer run
FLUTE (Fly-boat)	149' —	Plain stem, no head	Round stern Wales go to sternpost Square taffrail Outside rudder head	Small deadrise Slack bilges Large tumblehome all around	Full entrance Parallel midbody Finer run

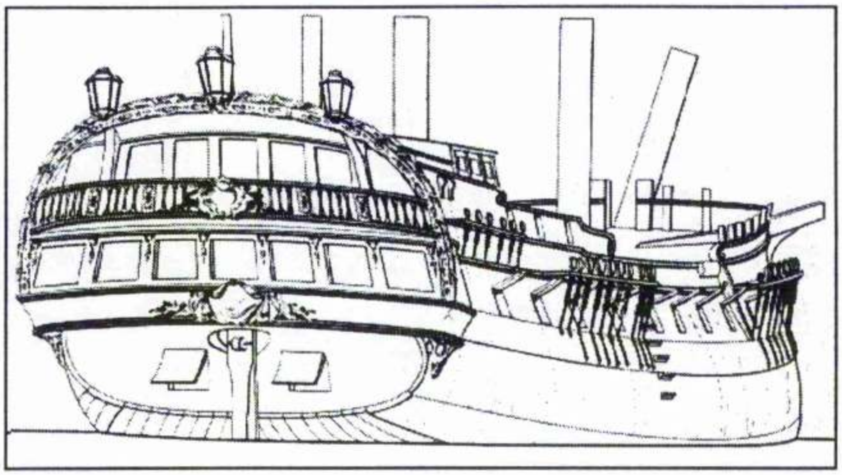


Figure 1.11. Detail of a Frigate (Plate III, Draught No. 3 from Chapman's Mercatoria, *1768)*

his *Treatise on Marine Architecture*, published in 1830, states that merchant vessels can be grouped into five classes according to increasing size and different usage: sloop, smack, schooner, brig and ship. Historians normally accept that by the early nineteenth century sailing vessels were normally referred to by their rig; however, this insight from Hedderwick suggests that differences in hull form and function were still significant to those in the shipping and shipbuilding industries. In the absence of an accepted nomenclature in contemporary treatises, this study will utilize Chapman's vessel classes, adding only the flute, as MacGregor has done.

Classification by Rig

By the eighteenth century a wide variety of rigs had begun to converge into more standardized configurations. At the same time, however, new designs were emerging and being assimilated into the pattern. The term *brig* was used to refer to several quite different two-masted rigs, including the brig, brigantine, hermaphrodite brig and snow. The fore-and-aft, two-masted schooner rig had begun to emerge, originating in the American colonies where it was favored because of its handiness and ability to work to windward. During this period, both brigs and schooners were two-masted and both carried a variety of square and fore-and-aft sails, making it easy to confuse one for the other. For the purposes of this study, only the major rigs used on English oceangoing vessels will be discussed.

Table 1.4 was developed to describe and summarize the seven principal rigs for oceangoing vessels in the eighteenth century, according to information from Chapman (1775), Falconer (1780) and Steel (1794). Figure 1.12 defines the seven rigs, along with illustrations showing typical configurations for each.

For the present study, it is necessary to quantify vessel attributes to the fullest extent possible, in order to permit comparative analysis of these attributes. The resulting analysis will then form a basis for developing a more precise description of the construction and evolution of merchant vessels. The following chapter attempts to develop a framework for more precise analysis of merchant sailing vessels.

Table 1.4

CLASSIFICATION OF EIGHTEENTH-CENTURY MERCHANT VESSELS BY TYPE OF RIG

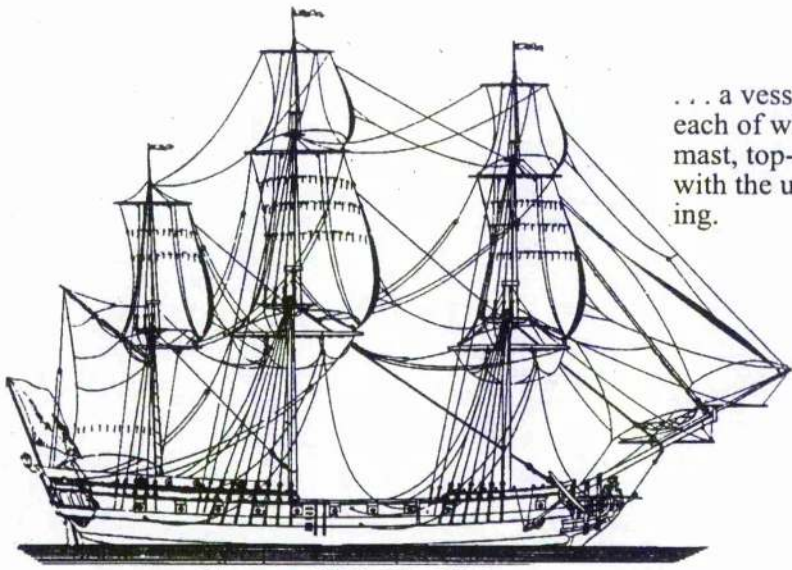
(From Chapman 1768 and Falconer 1780)

CLASS	AVG. SIZE	NO. MASTS	DESCRIPTION
Ship	Large	3	Each mast has 3 sections: lower, top and topgallant; square-rigged on all masts
Bilander	Large	3	Similar to a brig, but with a trapezoidal mainsail set on an angled yard (rare in late 18th/c.)
Brig	Medium	2	Square rigged on both masts; with a fore-and-aft mainsail set on a gaff and, usually, a boom (often called brigantine, although that term later applied to vessel square-rigged on the foremast only)
Snow	Medium	2	Similar to a brig, but setting its fore-and-aft mainsail on a small "try-mast" behind the mainmast to allow a square mainsail to be set
Ketch	Med.-Sm.	2	Similar to a ship-rig with the foremast removed
Schooner	Med.-Sm	2	Both fore- and mainsails set fore-and aft, but often carrying square upper sails
Sloop	Small	1	Fore-and-aft mainsail and triangular headsails

Note: See accompanying illustrations

FIGURE 1.12

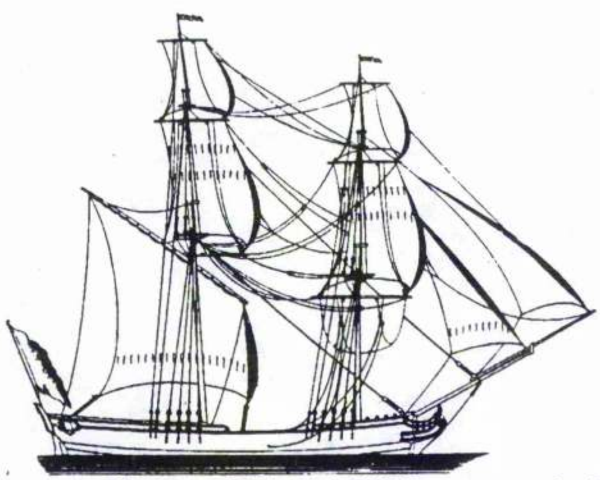
THE MAJOR TYPES OF EIGHTEENTH-CENTURY RIGS
(Definitions from Falconer 1780)



Chapman 1768, Pl. LXII.1

a. Ship

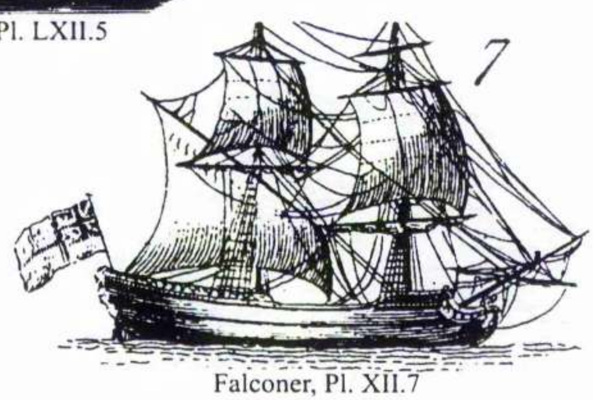
. . . a vessel furnished with three masts, each of which is composed of a lower mast, top-mast, and top-gallant-mast, with the usual machinery thereto belonging.



Chapman 1768, Pl. LXII.5

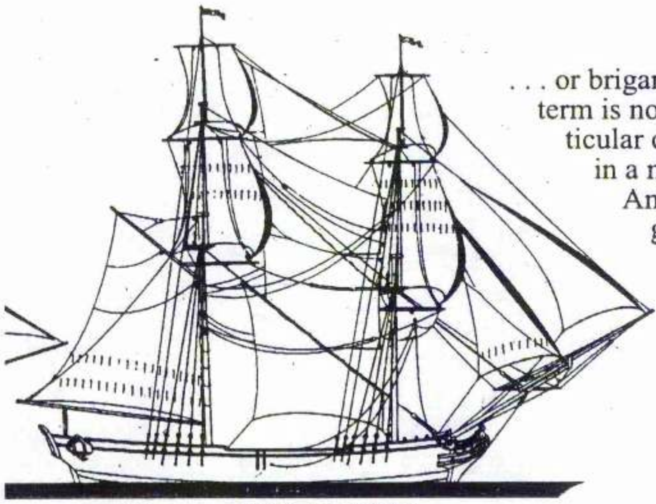
b. Bilander

. . . a small merchant ship with two masts . . . distinguished . . . by the form of her main-sail, which is a sort of trapezia . . . few vessels, however, are now rigged in this method . . ..



Falconer, Pl. XII.7

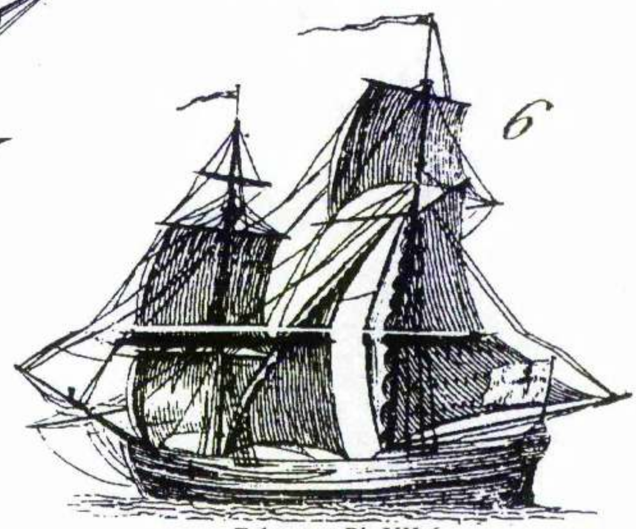
c. Brig



Chapman 1768, Pl. LXII.4

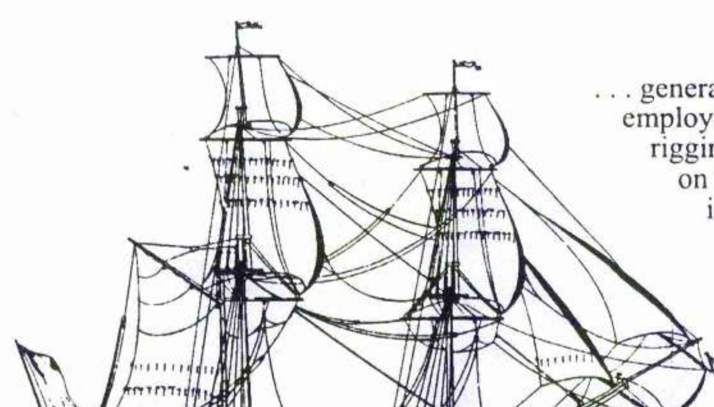
. . . or brigantine, a merchant-ship with two masts. This term is not universally confined to vessels of a particular construction, or which are masted and rigged in a method different from all others. . . .

Amongst English seamen, this vessel is distinguished by having her main-sail set nearly in the plane of her keel; whereas the main-sails of larger ships are hung athwart, or at right angles with the ship's length.



Falconer, Pl. XII.6

d. Snow



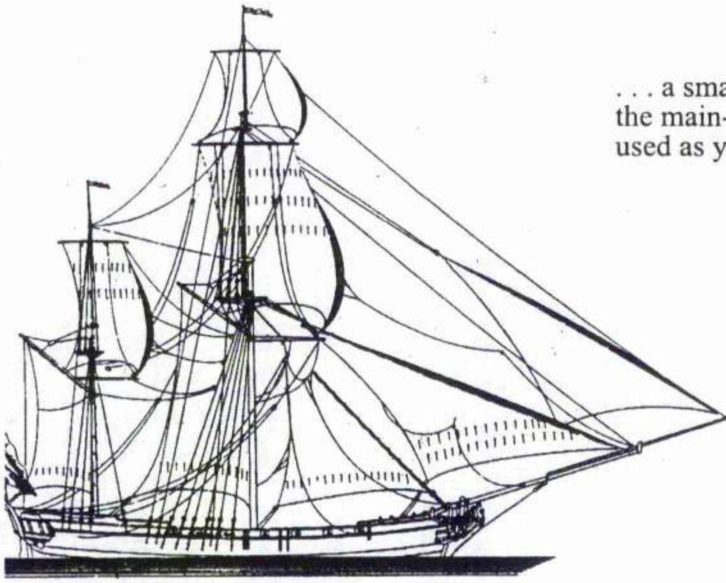
Chapman 1768, Pl. LXII.2

. . . generally the largest of all two-masted vessels employed by Europeans . . .. The sails and rigging of a snow are exactly similar to those on the same masts in a ship; only that there is a small mast [try-mast] behind the main-mast of the former, which carries a sail nearly resembling the mizen of a ship.

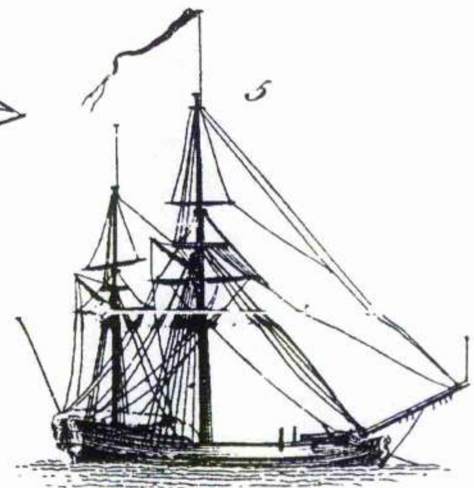
Falconer, Pl. XII.4

e. Ketch

. . . a small vessel equipped with two masts, viz. the main-mast and mizen-mast, . . . principally used as yachts, or as bomb-vessels . . ..



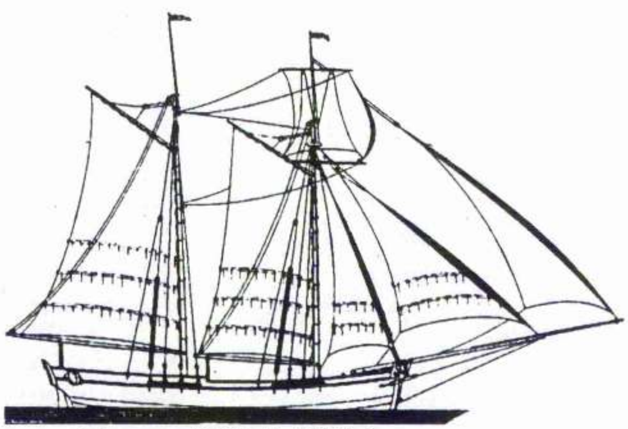
Chapman 1768, Pl. LXII.3



Falconer, Pl. XII.5

f. Schooner

. . a small vessel with two masts, whose main-sail and fore-sail are suspended from gaffs reaching from the mast towards the stern; and stretched out below by booms, whose foremost ends are hooked to an iron, which clasps the mast so as to turn therein as upon an axis . . ..

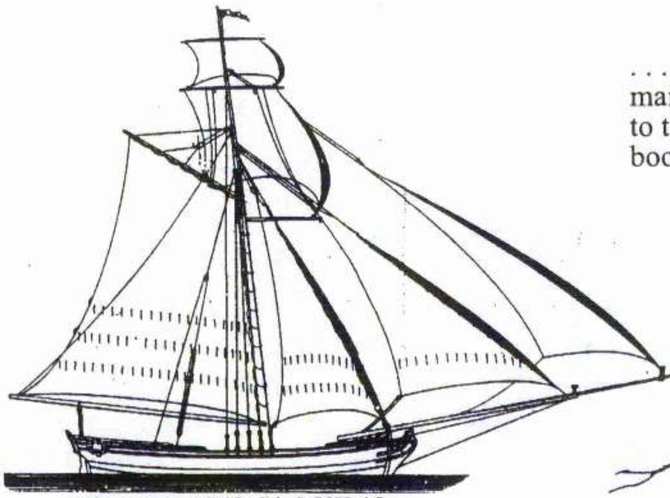


Chapman 1768, Pl. LXII.6

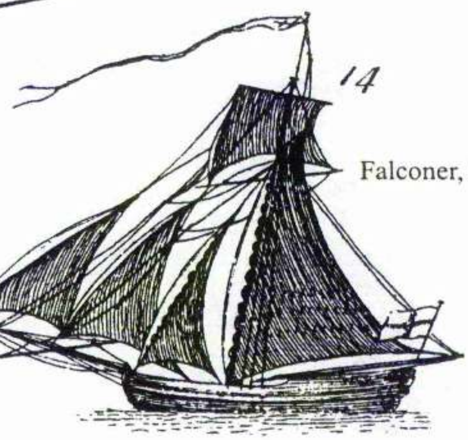
Falconer, Pl. XII.9

g. Sloop

. . . a small vessel furnished with one mast, the main-sail of which is attached to a gaff above, to the mast on it's foremost edge, and to a long boom below . . ..



Chapman 1768, Pl. LXII.12



Falconer, Pl. XII.14

Notes on Chapter 1

[1] This study uses the term "ship" both as a generic term for any large sailing vessel and in the more specific sense, which came into general use late in the eighteenth century, as a three-masted, square-rigged sailing vessel; the context should make the meaning clear.

[2] These and other nautical terms are defined in the Glossary.

[3] The term "ship" eventually came to refer specifically to a three-masted vessel, square-rigged on all masts.

[4] Appendix A offers a more thorough discussion of tonnage determination.

[5] It is important to note that in his *Mercatoria* Chapman groups all classes of vessels into four "species"—frigates, heckboats or pinks, barks or cats, and flat-bottomed vessels—offering an insight into his concept of related hull forms.

[6] All measurements have been converted from Swedish to English, using the following conversions:

1 Swedish fot = 29.7 cm , according to the Genealogical Society of Sweden (Harris 1989)

1 English foot = Swedish fot x 0.9744

English long tons = Swedish heavy lasts x 2.397 (Chapman 1768)

Note that the 1971 Praeger Publication facsimile edition of Chapman (1768) gives a value of 29.6 cm for the Swedish fot; however, the Harris (1989) value seems more correct. It should also be noted that numerous minor and several major discrepancies were discovered in the dimensions given in Chapman, which will be discussed in subsequent chapters. (See Appendix A for additional information on tonnage computation.)

Chapter 2

A Provisional Framework for Analysis

While Chapter 1 presented a broad, rather general discussion of the development of wooden sailing ships, subsequent chapters delve considerably more deeply into the design, form and construction of those vessels. Such in-depth treatment requires the employment of a basic suite of naval architectural terminology and mathematics; therefore, before proceeding, this chapter has been interjected to provide the reader with a provisional framework for analysis of merchant vessels.

Several scholarly publications, particularly Bass (1972, 1988), Greenhill (1976, 1988), Greenhill and Morrison (1995), Muckelroy (1980), Steffy (1994) and Throckmorton (1987), along with the National Maritime Museum's "The Ship" series and Conway's "History of the Ship" series, provide a solid foundation for understanding the development, technology and improvements in watercraft of all types, from antiquity to the age of steam and steel. There are many good books on modern naval architecture, including some good introductory texts (*e.g.*, Barnaby 1967; Benford 1991; Taggart 1980). Nevertheless, precise analysis of eighteenth-century vessels is handicapped by two major factors: lack of adequate contemporary documentation and lack of standardization among contemporary shipbuilders. Both of these shortcomings result in part from the lack of a mathematically-based theory of ship design during the period of interest.

Seventeenth- and eighteenth-century treatises on ship design and construction underscore the lack of universally-accepted rules and practices in private shipyards. In fact, even the construction of naval vessels appears to have been based as much on past successes and failures as upon a sound theoretical framework. By the middle of the eighteenth century numerous treatises on shipbuilding had been published and lively discussions and debates had developed around the various design theories being proposed. There is, however, no general agreement on the "ideal" hull form for naval or merchant vessels. For instance the French theorist Paul Hoste wrote in 1697,

> It cannot be denied that the art of constructing ships ... is the least perfect of all the arts ... the largest ships are often the most defective; and more good ships are seen amongst the merchantmen than in the royal navy.

A half-century later, Bouguer (1747:xviii) wrote,

> Experience would be the best means of perfecting naval architecture, if the thing were possible; but it is plain enough that practice is insufficient in many cases. It is certain, that if this alone is capable of rendering some parts perfect, it has need, in an infinity of others, to be aided by the light of theory.

Even as recently as the beginning of the nineteenth century the best method for determination of tonnage was disputed. John Charnock, in his three-volume *An History of Marine Architecture* (1800-1802:412), despairs that "it is impossible a true measurement ever can be made; and ... no certain method will ever be discovered of obtaining the true capacity of vessels ...."

To complicate matters further, there was even a general ambiguity concerning the terminology of basic hull forms and rigs through the end of the eighteenth century, the period of interest for this study. A single vessel might be referred to as a cat (a hull form), a bark (a hull form but also a rig) or a cat-bark.

Those contemporary treatises reveal the futility of relying heavily upon documentary sources for precise definitions and analysis. Even modern historians and naval architects tend toward subjectivity when discussing ships from the age of sail. For many maritime historians and even some nautical archaeologists, a limited general knowledge of naval architecture would be adequate if there were a more straightforward method of classifying and analyzing wooden ships.

In a concerted effort to create such a method, this chapter develops a provisional framework for the description, categorization and analysis of eighteenth-century sailing vessels, beginning with the development of a tentative vessel typology. Although it may be argued that this framework is somewhat oversimplified—even flawed—it proved to be a valuable tool during this study for the analysis of wooden sailing vessels and for development of testable hypotheses relating to those vessels.

A Provisional Framework for Vessel Classification

Given the difficulties described above, consideration was given to employing, at least loosely, the well-established principles of biological systematics, which are based on Darwinian evolution, to the analysis of recorded changes over time of the characteristics of sailing ships. This concept proved to be unproductive, given the limited database of information. Eventually, a collaborative effort by experts around the world could lead to the development of a "unifying theory" of the origins and evolution of ship and boat types throughout the world. Certainly, Greenhill (Greenhill 1976; Greenhill and Morrison 1995) and others have made great strides in that direction in the past two decades. Development of a "family tree" of vessel evolution based on a biological systematics approach is not an impossible goal; however, such an ambitious undertaking was seen to be beyond the scope of this study and, therefore, a more limited analytical approach was taken.

The vessel classification provided by Chapman (1768, 1775) and described by MacGregor (1988) (see Table 1.3) is the best and most comprehensive definition of eighteenth-century sailing ships available from contemporary sources. Riess (1987) used MacGregor's table of vessel characteristics (1988:29) in an attempt to place the "Ronson Ship," the remains of an early eighteenth-century merchant vessel, into an appropriate historical context. His analysis was limited, however, to a comparison of the visible hull remains with the characteristics seen in Chapman's plans and listed in MacGregor's table.[1] The goal of this present study was to develop a more structured method of determining hull type and defining key characteristics.

To achieve that goal, a data form, illustrated later in this chapter, was developed to simplify and standardize the types of data to be recorded for each vessel under study. Then a set of dendrograms, or decision trees, was developed to assist in determining the Chapman vessel class based on observable hull characteristics. (Refer to Table 1.3 for the classes and key characteristics.) If the entire vessel is preserved or is illustrated by lines plans, it may be possible to determine its class by following the dendrogram shown in Figure 2.1. If, as is usually the case with shipwreck remains, only the lower parts of the hull are available for study, it may still be possible to identify the hull class by following the dendrogram illustrated in Figure 2.2.

The above diagrams and others derived by the same method, are of only limited value, but will at least provide researchers with a quick and simple method for identifying and recording key hull characteristics and for performing a first-level classification exercise. Additional diagrams can also be generated, using other attributes as initial ones, depending upon the nature of the hull remains. In practice, however, such general characteristics as "moderately fine run" and "slack bilge" are too ambiguous for effective use by any but professional naval architects or reconstructors. Therefore, this study developed techniques for further quantifying the salient features of the hulls of wooden sailing ships.

Criteria for Merchant Vessel Hull Analysis

For the present study, a determined effort was made to quantify hull characteristics sufficiently to permit effective analysis and comparison. The principal criteria selected are based upon the availability of the necessary data, the difficulty of computing the variables, and their expected validity and applicability. The selected variables, both measured and computed, are referred to hereafter as vessel attributes. Although contemporary terminology is retained whenever possible, some of the attributes are based upon a modern assessment.

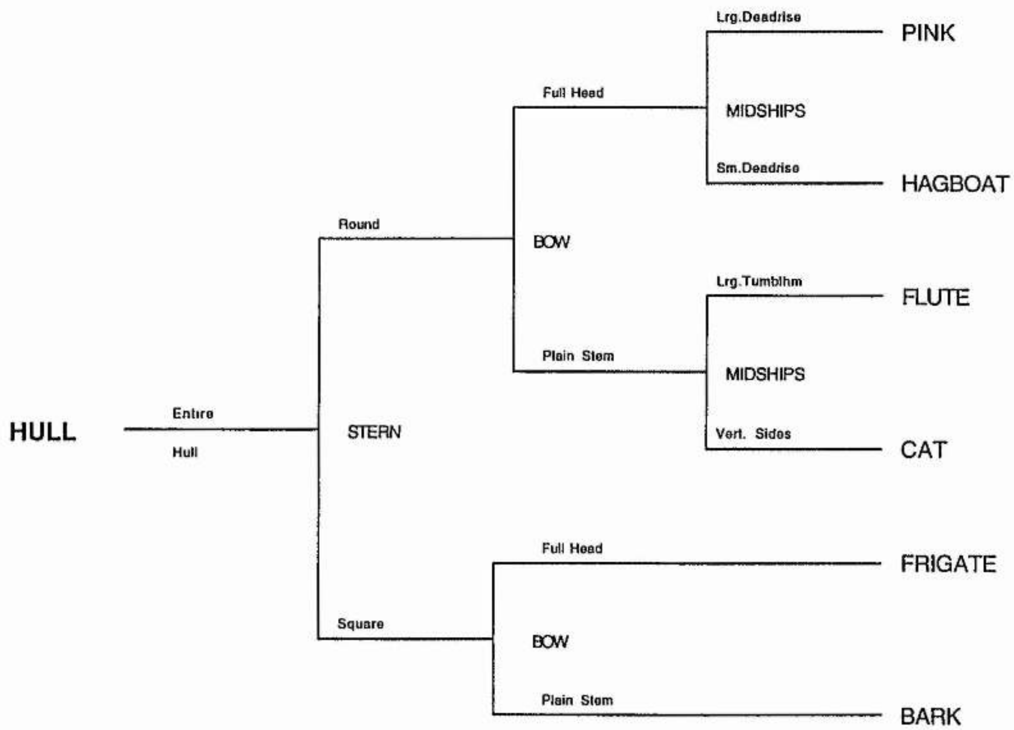


Figure 2.1. Dendrogram for identifying the hull classes of eighteenth-century vessels from lines plans

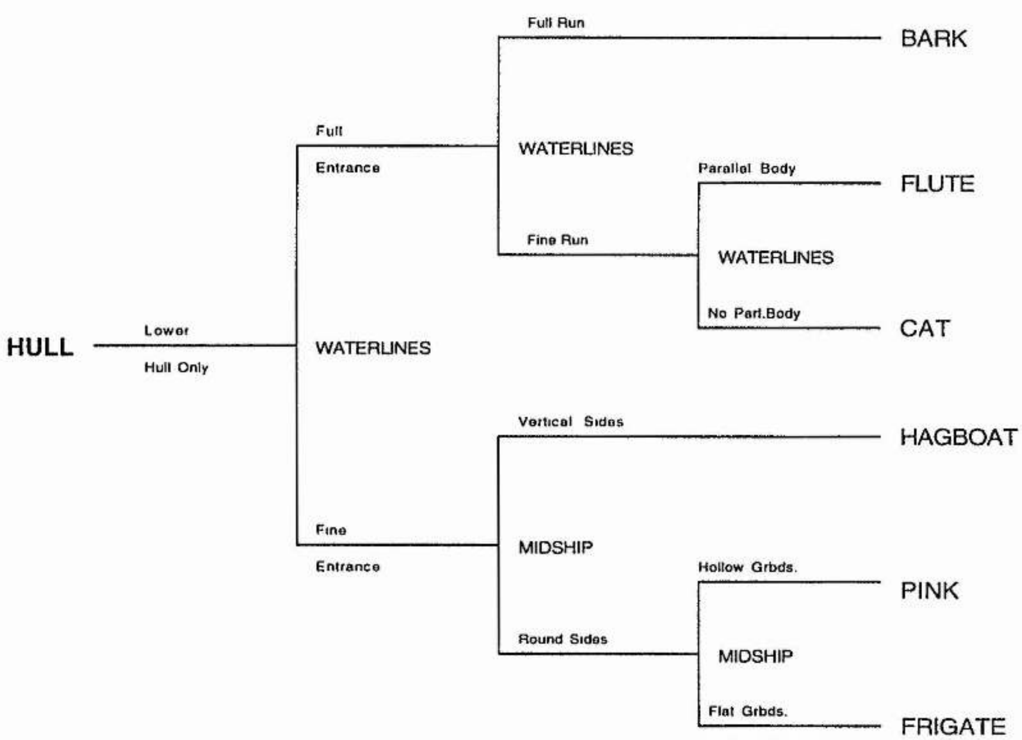


Figure 2.2. Dendrogram for identifying the hull classes of eighteenth-century vessels from hull remains

The selection of merchant vessel attributes for this study was heavily influenced by Howard Chapelle's *Search for Speed Under Sail* (1967), a pioneering analysis of American sailing ships that utilized the terminology of modern naval architecture for analyzing the design factors influencing speed in the age of sail. As his objective, Chapelle stated,

> By applying modern projections and some elementary principles of naval architecture and hydrodynamics to plans of American-built sailing vessels, it is possible to explore the development of the art of fast sailing ship and vessel design in North America (1967:xi-xii).

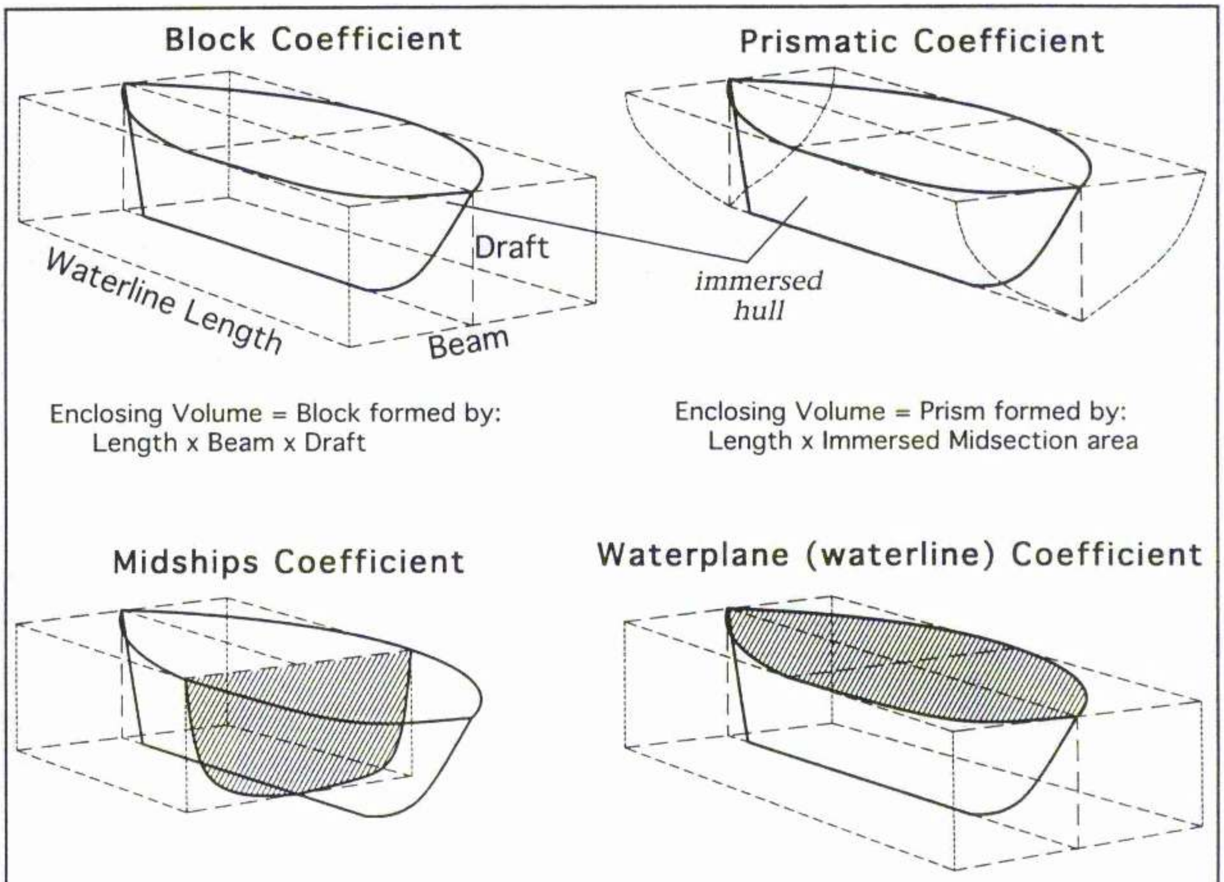
Chapelle (*Ibid.*) then defined the dimensionless coefficients that are most commonly used by modern naval architects to describe hull shape and, by inference, basic characteristics of function and performance. As illustrated in Figure 2.3, all four coefficients are ratios that render them dimensionless and, therefore, valuable for comparing hull forms of many different types, sizes and origins. Two of the coefficients, midships and waterplane (or waterline), are ratios of areas, which can be determined by fairly simple means. The remaining two, block and prismatic, are ratios of volumes, making them far more difficult and time-consuming to compute.

MacGregor, too, in *Fast Sailing Ships* (1988:20) attacks the problem of defining relevant criteria for determining the relative speed of sailing ships. However, MacGregor states that in his book,

> the plans submitted are not subjected to such close analytical study as to render the calculation of displacement essential, so the use of [block and prismatic] coefficients is not necessary (1988:20).

MacGregor (1988:20) went on to describe approximations he had developed for block and prismatic coefficients; unfortunately for the present study, the necessary data are available only for vessels dating after the first quarter of the nineteenth century.

In order to standardize recording and documentation during this study, a data form was developed and used throughout the analysis phase. Side one of the data form lists general information, basic dimensions, and general hull characteristics; side two provides space for additional measured and observed attributes as well as computed attributes. An analysis example, using the data form, is presented later in this chapter.



For this study the above dimensions are taken to represent the actual immersed hull, as follows:

> *Length* (L) is the length of the hull on the load waterline, to the rabbets of the posts,[3]
> *Beam* (B) is the maximum breadth on the load waterline, to the outside of the frames (molded breadth at the midship frame)
> *Draft* (D) is the mean draft from the rabbet of the keel to the load waterline.[3]

The coefficients are all dimensionless, making them very useful for comparisons. Referring to the above illustrations:

The *block coefficient* is the ratio of the immersed volume of the hull to the inclusive rectangle, defined by L x B x D,

The *prismatic coefficient* is the ratio of the immersed volume of the hull to the inclusive prism defined by L x the immersed midsection area,

The *midships coefficient* is the ratio of the area of the midship section to that of the inclusive rectangle defined by B x D, and

The *waterplane, or waterline, coefficient* is the ratio of the area of the hull shape at the load waterline to that of the inclusive rectangle defined by L x B.

John Broadwater:9/95

Figure 2.3. Four basic dimensionless coefficients used in naval architecture

Basic hull dimensions, unless provided in a historical reference, must be measured from draughts and models. Frequently, length, breadth, depth and tonnage are given, even when no additional data are available. It is important to ascertain the exact measurement being utilized so that all comparisons are "apples with apples." As straightforward as these attributes might appear, they can become quite confusing; for instance, "length" can refer to overall length, length between perpendiculars, length on the main (or upper gun) deck, length of the flat of the keel, or approximated length of the keel based upon "on-deck" measurements. Although length between perpendiculars is a common and seemingly straightforward measurement, it is not always clear where on the hull the perpendiculars were established. For instance, the perpendiculars of warships were usually taken to the rabbet of the posts at the height of the main gundeck, but with merchant ships, having much more variability in the height of their decks, the forward perpendicular was often taken at the height of the hawse holes. This study adhered to the definitions given in Figure 2.3, thus largely avoiding ambiguity and maintaining consistency.

In order to further quantify vessel characteristics, additional attribute definitions were developed, as illustrated in Figures 2.3 and 2.4 and defined in Tables 2.1 and 2.2. Most of the attributes are relatively self-explanatory; however, the dimensionless coefficients require additional definition. As stated above, the midships and waterplane coefficients are ratios of areas, while the block and prismatic coefficients are ratios of volumes. Determining areas and volumes can require time-consuming efforts and, especially in the case of volumes, can be extremely difficult. Methods for calculating areas and volumes can be found in numerous books on mathematics and naval architecture (Chapman 1775; Barnaby 1967; Taggart 1980); however this study identifies attributes that avoid much of the complex mathematics and can, therefore, be utilized by other researchers wishing to avoid the rigors of mathematical computations such as differential equations and integrals. Alternatives to mathematical and graphical approximations include planimeters, computer-aided drafting (CAD) systems and specialized ship-design software; however, these require special training and equipment that are not always available to researchers.

For this study an IBM-compatible personal computer and digitizing pad were used in conjunction with CAD software to generate a computer file for each set of ships's lines to be analyzed. The CAD program is capable of computing the value of any defined area, thus greatly simplifying the use of the selected attributes. The computer was also used for producing data files, tables and graphs.

Table 2.1
Measured Merchant Vessel Attributes

L_p	the length between perpendiculars; that is, between the after edge of the rabbet of the sternpost and the forward edge of the rabbet of the stempost at the level of the main gun deck (or, in merchant vessels, at the level of the upper deck or hawse).
L_{lwl}	the length on the load waterline, between the forward edge of the rabbet of the sternpost and the after edge of the rabbet of the stempost
B_e	the extreme breadth at the widest point on the hull, to the outside of the outer planking, exclusive of wales
B_m	the molded breadth at the widest point on the hull, to the outside of the timbers (frame faces)
D	the draught, or depth of the hull at the load waterline, measured from the rabbet of the keel; if the draught in bow and stern is not the same, mean draught is computed by adding the draught forward to the draught aft and dividing the sum by two

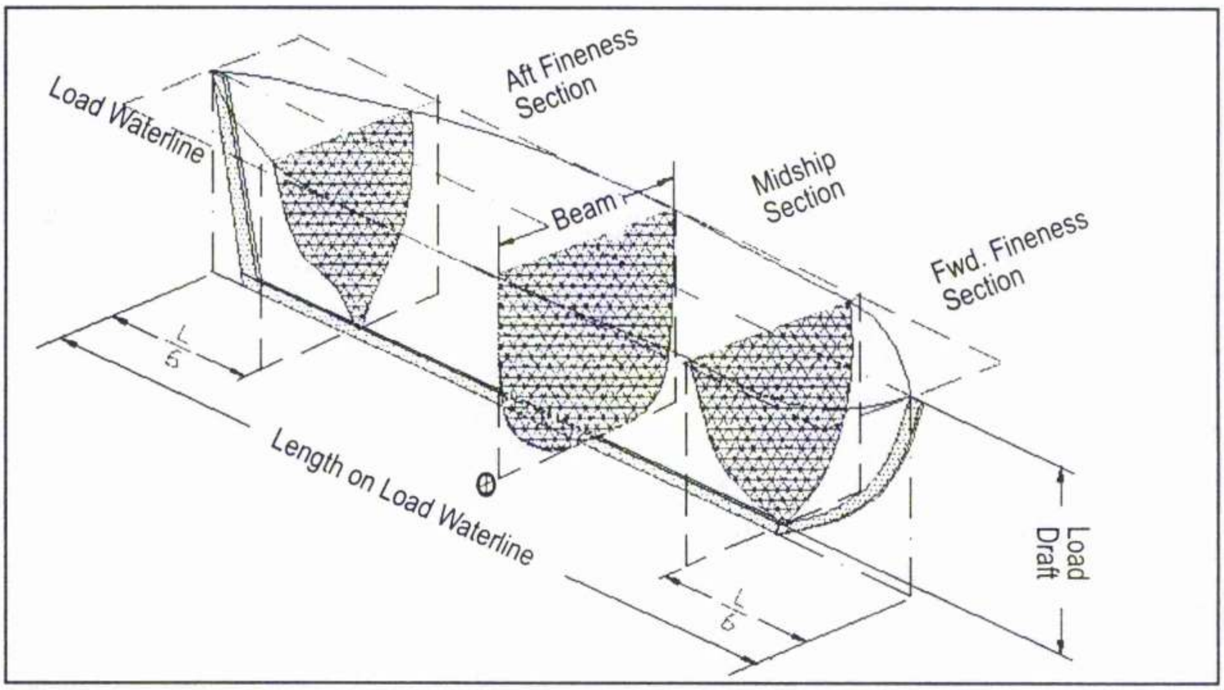


Figure 2.4. An illustration of key hull measurements used in this study

Area coefficients were retained, since the required areas can be determined much more easily than volumes and displacement. The volume coefficients commonly used by naval architects, block and prismatic, are effective in defining and comparing hull forms, but the difficulty of determining volumes limits their use by most historians and nautical archaeologists. Therefore for this study "fineness coefficients" were developed which provide similar analytical information to the block and prismatic coefficients, but require only the determination of areas instead of volumes. As illustrated in Figure 2.4 the "fineness coefficients" are derived from the areas of three hull sections. First, the length between perpendiculars is divided into six equidistant segments. The sections nearest stem and stern are termed, respectively, the forward fineness section and aft fineness section. The third

Table 2.2

Computed Merchant Vessel Attributes

T= tonnage, computed according to the Builder's Old Method (B.O.M.); that is, by the formula

$$\mathbf{T} = \frac{(L_p - 3/5\ B_e) \times B_e \times (B_e/2)}{94} = \frac{(L_p - 3/5\ B_e) \times B_e^2}{188}$$

L/B = Length/breadth ratio (L_p/B_e)

B/D = Breadth/depth ratio (B_e/D)

$\mathbf{A_m}$ = the area of the midship section

$\mathbf{A_{lwl}}$ = the area of the load waterline (waterplane) section

$\mathbf{A_{ff}}$ = the area of the forward fineness section

$\mathbf{A_{af}}$ = the area of the aft fineness section

$\mathbf{C_m}$ = midship coefficient = $\mathbf{A_m}$ / **A** (midships rectangle)
$\mathbf{C_{lwl}}$ = waterplane coefficient = $\mathbf{A_{lwl}}$ / **A** (lwl rectangle)

$\mathbf{C_{ff}}$ = Forward fineness coefficient = $\mathbf{A_{ff}}$ / **A** (midships rectangle)
$\mathbf{C_{af}}$ = Aft fineness coefficient = $\mathbf{A_{af}}$ / **A** (midships rectangle)

$\mathbf{C_{hf}}$ = Hull fineness coefficient $= \dfrac{\mathbf{C_{ff}} + \mathbf{C_{af}}}{2}$

section is taken at the midships frame, sometimes referred to as the "dead-flat" or "master couple" and usually indicated on the draft as $\oplus$. The forward and aft fineness sections are equidistant from the ends of the hull, but normally are not equidistant from the midships frame, which is almost always forward of the midpoint between perpendiculars. The fineness coefficients are derived from the areas of these three sections and that of the rectangle enclosing the midships section (which extends from the keel to the waterline, as shown).

These fineness coefficients proved to be useful and accurate indicators of relative hull fineness, comparable to the prismatic coefficient. The idea behind the fineness coefficients is that although hull shapes are variable and complex, they are confined within known limits by the fact that the lines must terminate at the ends of the vessel; therefore, three consistent and well-chosen cross-sections through the hull should provide a reasonable indication of overall hull shape. Regardless of the type of hull being studied, the fineness sections are located near enough to the ends of the vessel to detect the relative changes in hull form between the broad midships section and the diminishing ends. In addition to their relative ease of computation, the fineness coefficients also provide a means of assessing relative sharpness between the entrance (bow) and run (stern), which none of the modern coefficients address.

Although the fineness coefficients developed for this study are not conventional terms in naval architecture, they are similar to the revised method for computing tonnage adopted in 1836 (Lyman 1945:228-9; MacGregor 1988:97-8). Also, John Fincham (1825:21-22, 32-33) utilized similar sections, termed "balance sections," in designing ships's hulls. In Fincham's scheme, balance sections, located one-sixth of the length of the load waterline from stem- and sternposts, were drawn on the body plan, together with the midships section, to form the hull shape. This is at least a partial validation of the present study's fineness sections, since they were developed independently of Fincham's balance sections.

An Analysis Example

As an example to illustrate the above definitions and procedures, let us analyze Draught Number 1, Plate I, from Chapman's *Architectura Navalis Mercatoria* (1768). This draught illustrates a ship-rigged merchant frigate of 1268 tons burthen (Figure 2.5). Chapman provides the following dimensions in his English-language index to the draughts:

Length between perpendiculars of stem and sternpost (L_p):	160	feet
Breadth Molded (B_m):	41 $^5/_{12}$	feet
Draught of water as it is on the plan (D):	22 $^1/_{12}$	feet
The real burthen in tons, at the greatest draught of water:	1,268	tons

These values were entered on the data form, as shown in Figure 2.6.

Using the dendrogram developed in Figure 2.1, we can attempt to verify that this draught illustrates a frigate, as defined by Chapman. As shown in Figure 2.7, the dendrogram leads to the expected conclusion.

The following values were computed by Chapman but have been converted to English units:[5]

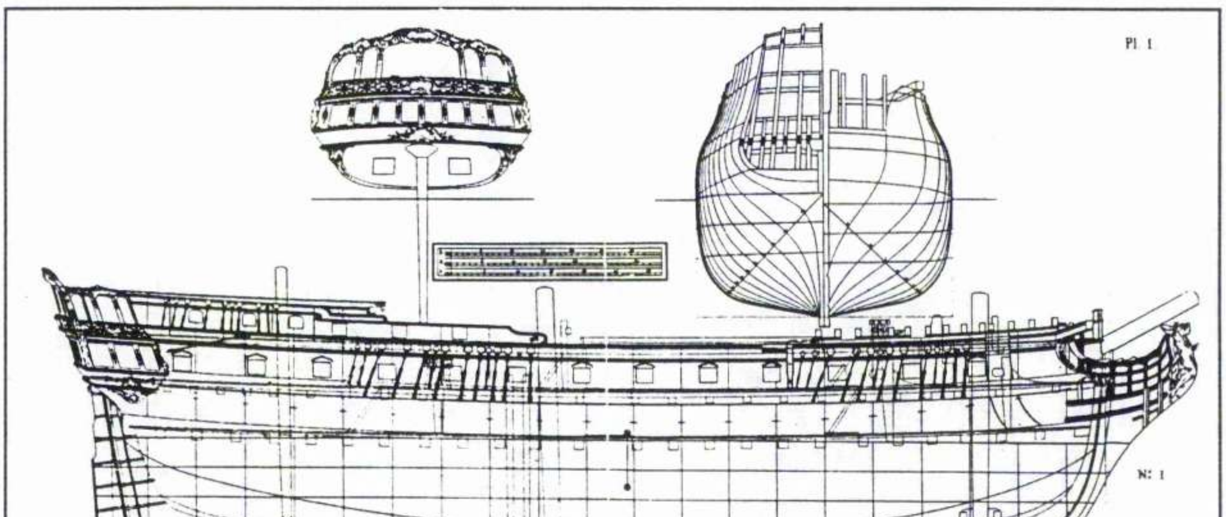


Figure 2.5. Frigate (Plate I, Draught No. 1 from Chapman's Mercatoria, *1768)*

18th CENTURY BRITISH MERCHANT VESSEL
DATA FORM

Side 1

BASIC DATA:

■ Vessel Name/I.D. Chapman Frigate I.1

■ Source of Data: ✓ Draught ___ Dwgg/painting ___ Model ___ Other ___

■ Reference (Publication/Location): Chapman (1768) Plate I, No. 1

■ Date surveyed: 5/5, 1994 ■ Surveyed by: J. Broadwater

BASIC DIMENSIONS (English Units):

■ Length:	✓	Between perpendiculars	159.8'
	✓	Load waterline	156.7'
	___	Main Deck	154.3'
	___	On Keel	141.2'
■ Breadth:	___	Extreme (outside of plank	___
	✓	Moulded (outside frame faces)	41.41'
■ Draught:	✓	Load waterline	23.31'
	✓	Other: As on plan	22.08'
■ Depth	✓	Depth in Hold	17.2'
■ Tonnage:	✓	Burthen (B.O.M.)	1268 tons
	✓	Other: per Chapman	1275 "

ATTRIBUTES: *Check all that are applicable (make notes where appropriate)*

■ **TYPE:** Hull: Frigate (merchant) ■ **Rig:** Ship

■ **STERN:** ___ Round (wales go to sternpost) ✓ Quarter galleries
✓ Square (wales go to wing transom or tuck) ✓ Square taffrail
___ Outside rudder

■ **BOW:** ✓ Full head ✓ Figurehead
___ Plain stem (no head) ✓ Cheeks ✓ Rails
___ Other ___

■ **WATERLINES:** Entrance: Full ___ Moderate ✓ Fine ___
Run: Full ___ Moderate ✓ Fine ___

■ **MIDSHIP:** Deadrise: Full ___ Moderate ___ Slight ✓
Bilges: Hard ___ Moderate ___ Slack ✓
___ Hollow Garboards ___ Parallel body midships
Tumblehome : Full ✓ Moderate ___ Slight ___

■ **Comments/Notes:**
Several apparent errors in Chapman's Tables, esp. Tonnage. Over ->

Figure 2.6a. Merchant Vessel Data Sheet, Side 1

18th CENTURY BRITISH MERCHANT VESSEL

DATA FORM

Side 2

Vessel Name: Chapman Frigate I.1

ADDITIONAL OBSERVED ATTRIBUTES:

- No. masts: 3
- Rig: Ship
- Hull type: Chapman class: Frigate Other: Merchant
-
-

COMPUTED ATTRIBUTES:

- Tonnage (Builder's Old Measure) = 1,268 tons
- Tonnage (Displacement) = ______ tons
- Displacement volume = 72,248 cubic feet
- Area of midship section = 677.0 square feet
- Area of load waterline section = 5,404 square feet

- L/B = Length/Breadth ratio = 3.86
- B/D = Breadth/Depth ratio = 1.78

- C_{lwl} = Load waterline coefficient = 0.85 (waterplane)
- C_b = Block coefficient = 0.48
- C_p = Prismatic coefficient = 0.68
- C_m = Midship coefficient = 0.87/0.70 *
- C_{ff} = Forward fineness coefficient = 0.64
- C_{af} = Aft fineness coefficient = 0.46
- C_{hf} = Hull fineness coefficient = 0.55
- Other ______ = ______

Additional Observations and Comments:

* M-ships coeff. determined from Chapman was 0.70, but graphical analysis produced a much larger value of 0.87

Broadwater:12/92

Figure 2.6b. Merchant Vessel Data Sheet, Side 2

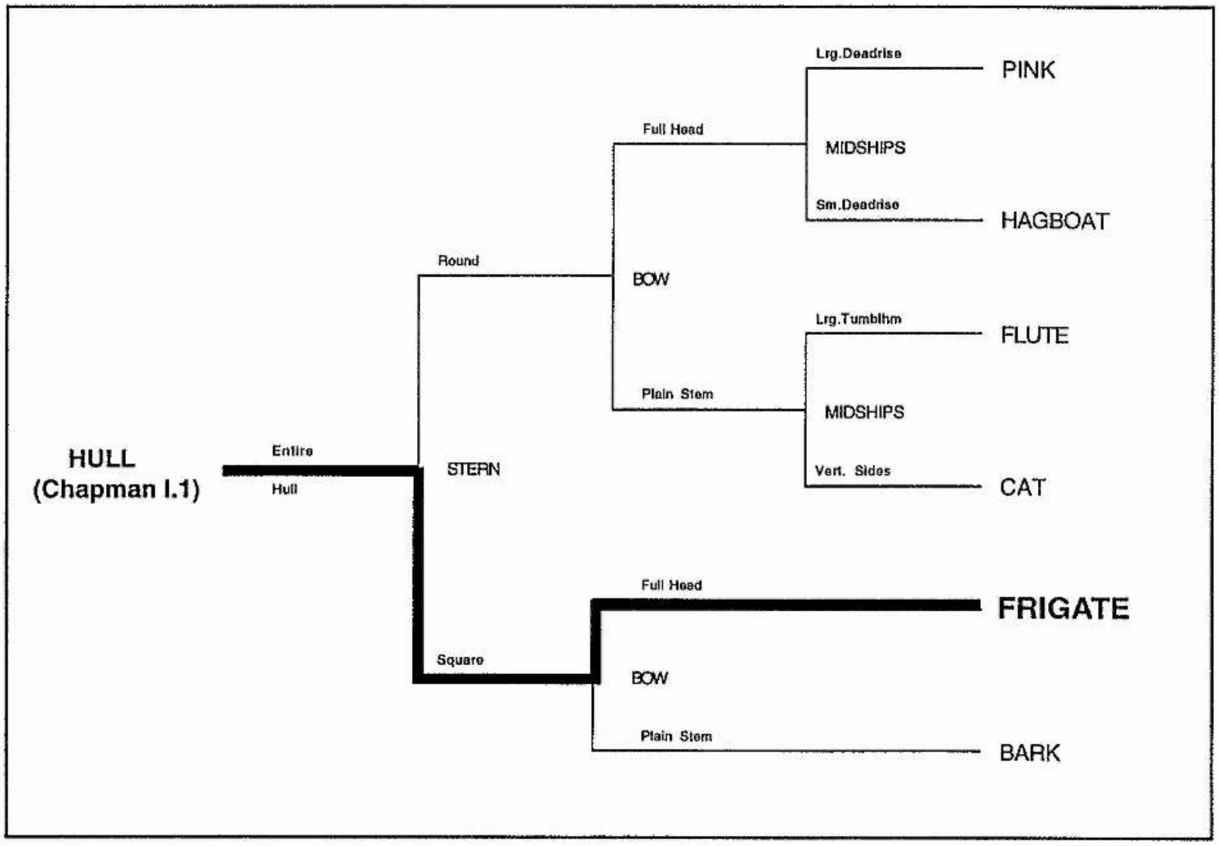


Figure 2.7. Dendrogram for example, verifying that Chapman Draught I.1 illustrates a frigate.

Area of the midships frame:	677.0 square feet
Area of the load waterline:	5,403.6 "
Displacement:	72,248 cubic feet

These values were also entered on the data form (Figure 2.6).

From this information, and using the English units scale on the draught, we can measure or compute the following additional attributes:

Length on the load waterline, L_{lwl}:	156.70 feet
Length-to-breadth ratio (L/B):	3.86
Breadth-to-depth ratio (B/D):	1.78

The block formed by the three basic hull dimensions is,

Block $= L_{lwl} \times B_m \times D = 156.7 \times 41.41 \times 23.3 = 151{,}257$ cubic feet.

Care must be used to select the correct values in computing the block. To be consistent in using Chapman's values, the block represents the volume formed by the maximum dimensions of the immersed portion of the fully laden hull; therefore, the dimensions used are the load waterline length, the maximum molded breadth and the laden draught. Molded dimensions are normally used, that is the dimensions taken from the lines, not taking planking thickness into account. Also, mean draught is generally used; however, we are using the fully laden draught for consistency with Chapman.

We can now compute the following dimensionless coefficients:

Block Coefficient $= \dfrac{\text{Displacement}}{\text{Block}} = \dfrac{72{,}248 \text{ cu.ft.}}{151{,}257 \text{ cu.ft.}} = 0.48$

Prismatic Coefficient $= \dfrac{\text{Displacement}}{\text{Area of midships section} \times L_{lwl}}$

$= 72{,}248 / (677.0 \times 156.7) = 0.68$

Midships Coefficient $= \dfrac{\text{Area of midships section}}{\text{Breadth} \times \text{Depth}} = \dfrac{677.0}{41.41 \times 23.31} = 0.70$

These coefficients are indicative of a moderately fine-lined vessel. However, Chapman's method of computing displacement involved somewhat inaccurate assumptions, so for the present the above computations should be thought of only as illustrative of the methodology. In fact, graphical analysis using a CAD system showed the midships coefficient to be a much larger 0.87 (see below).

Chapman gives tonnages derived from his own formula, which attempted to provide a true indication of the vessels's carrying capacity. However, his formula differed somewhat from that used officially for computing registered tonnage. For comparison, the tonnage can be derived from the standard eighteenth-century tonnage formula, which came to be known as the Builders' Old Method:[6]

Tonnage (B.O.M.) $= \dfrac{(L_p - {}^{3}/_{5}\, B_e) \times B_e \times (B_e / 2)}{94} = 1268$ tons, where L_p is the length between perpendiculars and B_e is extreme breadth to the outside of the plank, not including wales. Plank thickness can be easily estimated from contemporary scantling tables.

The resulting value for B.O.M. tonnage raises suspicions, since B.O.M. tonnage for a given vessel is nearly always lower than the actual carrying capacity, as supposedly represented by Chapman's "real burthen" (Ville 1989:65-83), yet Chapman listed the real burthen of this ship as 1140 tons. Therefore, as a check, Chapman's tonnage value of 532 Swedish lasts was converted directly to English tons using the accepted multiplier of 2.397 tons/last, which yielded a burthen of 1275 tons, slightly higher than the B.O.M. tonnage and considerably above the 1140 tons given by Chapman. A further check of Chapman's ten frigate draughts revealed that the tonnage values from Chapman's English table were consistently lower than the actual values given in Swedish lasts. Even stranger is that the error is not consistent, ranging from approximately 6% to 14% for the ten frigates, indicating that the discrepancy is not merely one of converting between English and Swedish tons.

The discovery of these errors prompted further scrutiny of Chapman's published numbers. Other errors were also discovered, some relatively minor but several of significance. The errors apparently resulted primarily from carelessness in preparing the English-language index; however, errors were also found in the Swedish index. As a result of these findings, all measurements to be used for analysis and comparison in the present study were lifted directly from the draughts in an original copy of Chapman's *Mercatoria*.[7]

Let us turn now to the determination of the fineness coefficients, which will be taken directly from the draught and are not, therefore, subject to errors in Chapman's tables. One-sixth of the load waterline length is 156.7 ft. / 6, or 26.12 feet. Marking off that distance from bow and stern perpendiculars, we establish the three fineness sections as follows (see Figures 2.5 and 2.8):

Midships section located 66.7 feet aft of the bow extent of the load waterline (11.85 feet forward of the midpoint on the load waterline),

Forward fineness section located between stations P and Q, and

Aft fineness section located between stations 24 and 25.

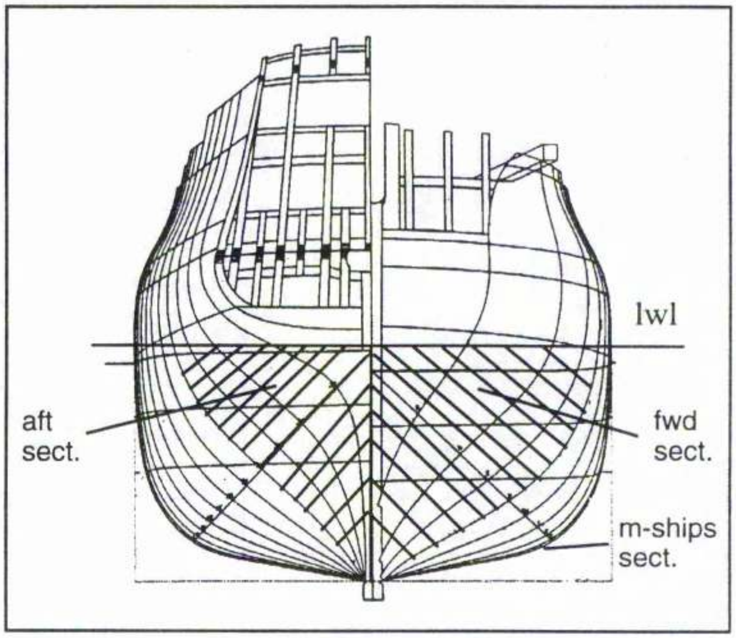


Figure 2.8. Frigate body plan (Plate I, Draught 1, Chapman, 1768), indicating fineness sections.

The areas of the three sections are determined from the body plan using a CAD system with a digitizing pad. The midships section is digitized directly from the body plan, following the half-section from the centerline across the load waterline and along the curve of the midships body section. The area of this half-section is determined directly from the CAD program. In the same manner we derive the area of the limiting rectangle bounded by the centerline, load waterline, load draft and molded beam, again using a half-section for consistency and simplicity. The procedure is repeated for the forward section between stations P and Q, then for the stern section between stations 24 and 25. Half-sections are especially convenient here, since conventional body plans show bow half-sections to the right of the centerline and stern half-sections to the left. Although dimensional units can be calibrated from the scale on the draught, the units may be ignored if only coefficients are being sought, since the coefficients are dimensionless. The ability to ignore dimensional units increases the utility of coefficients.

Once the areas have been determined, all to the same scale, the fineness coefficients are easily computed as follows:

$$C_m = \textbf{Midships coefficient} = \frac{\text{Area of the midships section}}{\text{Area of its limiting rectangle}} = \frac{420.1}{482.6} = 0.87$$

$$C_{wl} = \textbf{Waterplane coefficient} = \frac{\text{Area of the load waterline (plan)}}{\text{Area of the limiting rectangle}} = \quad = 0.85$$

$$C_{ff} = \textbf{Forward fineness coefficient} = \frac{\text{Area of the bow fineness section}}{\text{Area of midships limiting rectangle}} = \frac{308.9}{482.6} = 0.64$$

$$C_{af} = \textbf{Aft fineness coefficient} = \frac{\text{Area of the stern fineness section}}{\text{Area of midships limiting rectangle}} = \frac{221.9}{482.6} = 0.46$$

From these values, we can define another coefficient:

$$C_{hf} = \textbf{Hull fineness coefficient} = \frac{\text{Cff + Caf}}{2} = \frac{0.64 + 0.46}{2} = 0.55$$

These values, determined graphically, are considered to be more accurate than those computed using values given by Chapman. We have now computed all the basic coefficients and these, too, are recorded on the data form (Figure 2.6).

Summary

This chapter has outlined a provisional framework for analysis of hull forms, using relatively simple and straightforward graphical and mathematical methodologies. A data form is presented for use in recording hull information in a consistent manner. A series of "fineness coefficients" is proposed for use in defining hull shape using only simple mathematical and graphical analyses. A preliminary comparison between the proposed fineness coefficients and the more conventional volumetric coefficients suggests that the fineness coefficients yield similar results.

As an example, a frigate plan from Chapman's *Mercatoria* is analyzed, using the proposed methodology. The next step, presented in later chapters, is to utilize this framework for analysis to define and compare eighteenth-century hull forms from a variety of sources.

Although this study also presents an analysis of the major types of rig and compares mast and spar dimensions, there was not an adequate basis upon which to build a comprehensive framework for analysis similar to that for hull form.

Notes on Chapter 2

[1] The Ronson Ship is discussed more fully in Chapter 7.

[2] The term "length" can apply to numerous measurements, and contemporary sources often neglect to define the term; the present definition was chosen in order to maintain consistency and to utilize the most relevant dimension.

[3] Molded dimensions are usually used, that is, the maximum beam to the outer (molded) face of the frames at the midships frame. However, it should be noted that planking adds to the beam, thus increasing hull volume; therefore, with conventional calculations of tonnage, the measurement is taken to the outside of the planking, but disregarding wider wales.

[4] Eighteenth-century ships generally were designed and trimmed for a deeper draft aft, but the "waterlines" on draughts, or plans, were nearly always parallel to the rabbet of the keel; therefore, for analysis purposes mean laden draft is a more valid term.

[5] All measurements have been converted from Swedish to English values, using the following conversions:

1 Swedish fot = 29.7 cm , according to the Genealogical Society of Sweden (Harris 1989)

1 English foot = Swedish fot x 0.9744

English long tons = Swedish heavy lasts x 2.397 (Chapman 1768)

Note that the 1971 Praeger Publication facsimile edition of Chapman (1768) gives a value of 29.6 cm for the Swedish fot; however, the Harris (1989) value seems more correct. It should also be noted that numerous minor and several major discrepancies were discovered in the dimensions given in Chapman, which will be discussed further.

[6] See Appendix A for additional information on tonnage computation.

[7] An original copy of Chapman's *Mercatoria* was used in this study, along with the 1820 English translation of his *Treatise on Shipbuilding*. Reference was also made to the original Swedish edition of the *Tractat* (*Treatise*) when there was doubt about a formula or numerical value. All three sources were examined in the research library of The Mariners' Museum, Newport News, Virginia.

Chapter 3

Primary Sources of Information on Eighteenth-Century Merchant Vessels

This study has accumulated a surprisingly rich and varied amount of information on ship design and construction from the eighteenth and even late-seventeenth centuries. These data were found almost exclusively in repositories and private collections in Great Britain, with the exception of some of the more popular published eighteenth-century sources. Several previously-unknown private collections came to light during this research, contributing significantly to a more complete and accurate picture of merchant shipping and shipbuilding in English ports. Undoubtedly, even more records survive in private collections, many of which may never be available to scholars.

This chapter discusses, compares and analyzes the principal primary sources examined during this study, including contemporary treatises on naval architecture and shipbuilding, Admiralty records, port registers, *Lloyd's Register of Shipping*, and draughts, plans, paintings and models.

Early Treatises on Naval Architecture and Shipbuilding

The first known printed work on European shipbuilding is *Instruction Nautica ...* by Diego Garcia de Palacio, published in Mexico City in 1587 (Bruzelius 1992:iii). By the late sixteenth century, scholars in Europe had begun to seek a theoretical framework as well as mathematical formulations to describe and define the "art" of shipbuilding. In his *His-*

tory of Naval Architecture, John Fincham (1851:xiii) states that the "importance of placing the operations of naval architecture on a less uncertain basis" prompted a series of conferences on the subject, held in Paris in 1681. By the end of the century, many treatises had been published, primarily in France, but also in England, Germany, Holland and Scandinavia, on the theories of such topics as the resistance of various hull forms through water at different velocities, optimum angles between sails and wind, and optimum wind angle for maximum velocity.

By 1791 so many treatises had been generated that *European Magazine* published an annotated bibliography of papers on naval architecture. This document described the papers under the headings "writings relating to the theory of the art of ship-building" and "writings relating to the practice of the art of ship-building." Although the list is not exhaustive, it does provide a valuable summary of early publications, as well as an assessment of the "state-of-the-art" in European ship design and construction at the end of the eighteenth century (*Eur.Mag.* 1791). The assessment must be interpreted with some reservations, however, since the author's objectivity seems somewhat doubtful and since he has omitted from his discussion some very important early works on shipbuilding, including Mainwaring, Bushnell and Deane.[1]

In addition to the *European Magazine* review, two modern researchers have generated very useful bibliographies of early treatises on shipbuilding. R. C. Anderson wrote two excellent articles for the *Mariner's Mirror* (X[1924]:53.64; XXXIII [1947]:218-25) in which he summarizes early books on shipbuilding and rigging. In 1992, Lars Bruzelius compiled a very detailed "Bibliography of Books on Naval Architecture, Rigging and Seamanship Printed 1600-1919" which is still in manuscript form.[2]

Among the earliest English works were "A Treatise on Shipbuilding," ca. 1620, an anonymous manuscript, and "A Treatise on Rigging," another anonymous manuscript which Anderson dated to ca. 1618-37;[3] Sir Henry Mainwaring, *The sea-man's dictionary*, written between 1620 and 1623 but not published until 1644; and John Smith's *An accidence ... for all young sea-men,* 1626 (and a later version revised by another author and published under the title *The Seaman's Grammar*). Anderson (X [1924]:56) also lists another book as "an authority of first-class importance," Nathaniel Boteler's *Six Dialogues About Sea Services* (1634).

According to the *European Magazine* article the first person to calculate the resistance of a ship through water was the Reverend Father Ignacius Gaston Pardies, of the Society of Jesus, who first published his treatise in 1673 (Pardies 1673). For five decades Father Pardies's theories were debated in print by other writers including Renau, Huygens, and John and James Bernoulli. The bibliographer warned that some of these writers "had not the slightest practical knowledge of nautical things" and, therefore, their writings were not recommended to the reader (*Eur.Mag.* 1791:12).

In 1697 an important French work on the theory of naval architecture was published by another Jesuit, Paul Hoste, professor of mathematics at the Royal Seminary of Toulon. In assessing the state of naval architecture at the end of the seventeenth century, Hoste noted,

> The best constructors build [ships] almost entirely by eye; whence it happens that the same constructor, building at the same time two ships after the same model, most frequently makes them so unequal, that they have quite opposite qualities. ... the largest are often the most defective; and more good ships are seen amongst the merchant-men than in the royal navy (Hoste 1697, quoted in Fincham, 1851:xv).

Shortly thereafter, in 1702, Aubin published his *Dictionaire de la Marine*, in which he attempted to summarize current ship design and shipbuilding knowledge (Harris 1989:12).

Of these early treatises, the *European Magazine* summary states, "All that had been treated hitherto in writings of the theory of ship-building were single objects, and solutions of detached problems." The article then credits M. Bouguer with publishing, in 1747, "a truly classical work" which for the first time collected the various theoretical topics of shipbuilding into a single, comprehensive volume.[4] Although writing a half-century later, Bouguer confirmed that Hoste's pessimistic views remained valid:

> [Shipbuilders] think differently from each other; and yet each alleges, with equal confidence in his favour, his own practice .... As it is impossible to reconcile them, because they have no means of doing it, neither common principle of agreement from which they can set

> out, nor rule, nor even index to discern the truth by, or to bring them acquainted with it, they are reduced to a continual repetition of the same assertions in the place of proofs (Bouguer 1747:xviii, quoted in Fincham, 1851:xxi-xxii).

According to Fincham and others, theoretical naval architecture in England lagged behind that of Europe:

> Inquiry into the theoretical conditions of ship-building was almost wholly confined to the mathematicians of the continent of Europe, engaging scarcely any regard in England during the whole of the [eighteenth] century, until nearly its close ... (Fincham 1851:xlii).

Notwithstanding Fincham's statement, however, a number of valuable English treatises were produced before the end of the eighteenth century, even if they were more concerned with the practical than the theoretical aspects of shipbuilding. Since these treatises are an essential element in establishing an accurate picture of eighteenth-century English merchant ships, they are briefly examined here, with special emphasis on those sources which contain specific information on merchant vessels.

A Review of Early English Treatises on Shipbuilding

The earliest known English manuscript on shipbuilding is "Fragments of Early English Shipwrighty," attributed to Matthew Baker, c. 1585.[5] The treatise contains relatively little detailed information on naval architecture and even less on merchant ships, but it is useful because of its early date. Sir Henry Mainwaring's *The Sea-Man's Dictionary*[6] was apparently written between 1620 and 1623 (Anderson (X (1924):55; Lavery 1988:9). There were various editions and the dictionary contains useful information on early shipbuilding methods. In 1664, Edmund Bushnell published *The Complete Shipwright*, "the first printed work in English dealing purely and simply with naval architecture" (Anderson 1924:59). Although it is brief and its illustrations leave much to be desired, the treatise is clearly and concisely written. Bushnell describes in detail the designing of a ship of 60 feet on the keel, giving a sheer draught and midship section, along with notes on "laying off." The book, reprinted in 1716, claims to offer proportions actually used by experienced shipwrights. In 1670, Sir Anthony Deane prepared an important manuscript entitled, "Doctrine of Naval Architecture."[7] The title page of this unpublished manuscript states that it was "written in the year 1670 at the instance of Samuel Pepys Esq." Although not actually published until more than three centuries later (Lavery 1981), Deane's treatise was known by his contemporaries. Deane's "Doctrine" and Bushnell's *Treatise* together provide a relatively clear picture of the basic elements of ship design during the second half of the seventeenth century. The first English work on the practice of shipbuilding mentioned in the *European Magazine* article is *The Accomplished Shipwright and Mariner*, published in 1706 by John Hardingham. The bibliographer did, however, list the titles of other books "of which I am not able to give any further notice than only of their existence" (*Eur.Mag.* 1791:23).

William Sutherland's *The Ship-Builders Assistant (1711)*[8] is generally considered to be the first published English work which treats the subject of naval architecture in detail. In the Preface Sutherland relates that he and "several forebears" worked in Royal Navy yards, but that his book may be "very advantageous to Merchants, Owners, and any others concerned in Shipping ...." In spite of that statement, his treatise is essentially about warships. Apparently, the book was widely known, as Sutherland revised and reissued it several times before the final version was published in 1784. The book also includes such practical information as sparring and rigging proportions for vessels built just after the turn of the century. In 1717, Sutherland published a second important work, *Britain's Glory: or, Ship-Building Unvail'd.* This book, in two parts, contains sound practical advice for the shipbuilder, including detailed information on contracting for every facet of building a ship. Sutherland's two works provide a very detailed description of ship design technology at the beginning of the eighteenth century.

Mungo Murray's *A Treatise on Ship-building and Navigation* (1754), and *Supplement to the Treatise on Ship-building* (1765) are clearly written and include extensive information and tables of proportions on merchant ships ranging from 50 to 630 tons. The supplement, published in 1765, includes translated portions of two important French treatises: an abridged version of M. du Hamel's *Elemens de l'Architecture Navale*, 1752, which *European Magazine* termed "by far the best practical work in [the French] language" (*Eur.Mag.* 1791), but which deals only with ships of the line, and part of M. Bouguer's

Traitè du Navire, 1747, mentioned above. Murray was a shipwright at Deptford, where numerous merchant ships were measured and fitted out as naval transports. Therefore, although he was primarily concerned with the construction of warships, his probable experience with naval transports gives credibility to his comments on the design and construction of merchant vessels. His treatise clearly explains the principles of preparing draughts and then explains the process of projecting the draughts to the molding loft. The principle of whole-molding (moulding) is explained, including its application to the design of large vessels. The 1765 supplement to the treatise also contains, among other additions, a table of masting dimensions for a variety of merchant ships.

Two of the best-known publications on eighteenth-century ship design are by Fredrik Henrik af Chapman. Chapman was the son of a British naval officer who had joined the Royal Swedish Navy and who in 1720 became captain of the Royal Dockyard at Gôtteborg. His *Architectura Navalis Mercatoria* (1768), and *Tractat on Skepps-Byggeriet* (1775) are probably the best and most complete sources of information on English and European merchant ships from that period. Chapman's publications contain extensive information and draughts of English merchant ships, which he had studied in detail. Since Chapman's *Tractat on Skepps-Byggeriet* (*Treatise on Ship-Building*) was not translated into English until 1820, it is not known what influence the treatise had in Great Britain prior to that date. However, it is almost certain that the extremely high quality draughts and illustrations in Chapman's *Architectura Navalis Mercatoria* were widely known in England. The draughts, displayed on 62 engraved plates, are very detailed, represent an impressive variety of sizes and types of merchant vessels, and include scales for English, French and Swedish measurement units.

The eighteenth century produced two excellent dictionaries of nautical terms: Thomas Blanckley's *Naval Expositor* (1750) and William Falconer's *An Universal Dictionary of the Marine* (1769). Falconer's dictionary provides detailed definitions of a wide variety of English and French nautical terms. In addition to definitions, the dictionary contains a 13-page summary essay under the heading "Naval ARCHITECTURE," as well as another three-page essay entitled "Ship-BUILDING." For his articles on "the theory and art of ship-building" Falconer credits M. Du Hamel's *Elements of Naval Architecture*. This excellent and widely-used source was reissued several times during the eighteenth century.

William Hutchinson's *A Treatise on Practical Seamanship* (1777)[9] does not deal with naval architecture in detail, but it is valuable for the vital information he provides on the preferred characteristics of merchant ships, especially colliers and other bulk-cargo carriers. This treatise is an essential element in the attempted analysis of late eighteenth-century merchant ships. Unlike most of the other authors, who worked in the London area, generally for the Royal Navy, Hutchinson was born in Newcastle-upon-Tyne and went to sea as a boy aboard a north-built collier. Therefore, his perspective on shipbuilding is especially important to the present study.

The latter part of the century produced other valuable English treatises, many of which contained detailed information on merchant vessels. Marmaduke Stalkartt's *Naval Architecture, or the Rudiments and Rules of Ship Building* ... was credited by the *European Magazine* bibliography (1791:31) as being "the amplest and most satisfactory" of the treatises then in print for the instructions for preparing draughts and transferring them to the mold loft, as well as for the high quality of the large-size plates, which had "no rival among all mentioned ...." Stalkartt's treatise was also the first to publish plans for a wide range of vessel types, including a yacht, sloop and cutter, as well as several warships. *The Shipbuilder's Repository; or, a Treatise on Marine Architecture* ..., published anonymously in 1788, contains an excellent shipbuilding section with emphasis on merchant vessels. In it are presented tables of proportions and scantlings for merchant ships of all sizes, in addition to those for warships. The author also presented ten design criteria for merchant ships, followed by proportions for four "classes" of merchant ships ranging from 100 to 800 tons. In 1794, William Hutchinson published *A Treatise on Naval Architecture ... of Merchant Ships in general....* Hutchinson's treatise is particularly important for this study because its subject is merchant ships. Hutchinson describes current merchant ship design practices and suggests improvements. He also illustrates merchant ship lines and provides proportional data and tables for design and construction. The Third Edition of *Encyclopaedia Britannica*, published in 1797, includes an extensive "Ship-Building" section that is useful because it presents design and construction information from a variety of sources.[10]

At the beginning of the nineteenth century, David Steel published two valuable books on shipbuilding: *The Elements and Practice of Naval Architecture* (1805), and *The Shipwright's Vade-Mecum* (1805). Steel's *Naval Architecture* is a detailed and superb work, a quarto book with a separate set of folio plates of excellent quality, describing a variety of warships and merchant ships. Of particular significance to the present study is Steel's description of a "collier brig" of 170 tons. In presenting nautical design information, Steel separately lists proportions for warships and merchant vessels, which is very helpful in making a comparative analysis of the two vessel types. Since Steel's *Naval Architecture* was published in 1805, it seems logical to assume that the book can be viewed as a benchmark for naval architecture at the end of the eighteenth century. MacGregor (1988:16) cautions, however, that much of Steel's section on ship design, including forming midship sections with arcs of circles, seems to have been taken from earlier works, either *The Shipbuilder's Repository* or a later edition of Sutherland's *Ship-builders Assistant.*

Two other early nineteenth-century books offer information relevant to this study. John Fincham's *An Outline of Ship Building* (1821) reviews several different methods used in England and France for forming the midship section, offering comments on the advantages, disadvantages and current usage of each method. The book also presents an excellent item-by-item description of every part of a ship. Peter Hedderwick's *A Treatise on Marine Architecture* (1830) is well illustrated with 21 separate large-size plates. The entire work concentrates on merchant ships. In Hedderwick's own words:

> The Publications on Marine Architecture, though written by the most able men in the profession, have been hitherto almost entirely adapted to Ships of War, or Merchant-Vessels of the largest dimensions; while the smaller classes, by which the commerce of the different countries of Europe is chiefly carried on, have been greatly neglected.

Although not published until 1830—after some significant changes had occurred in naval architecture—the book describes ship design in terms of both old and new methods. Because of Hedderwick's incorporation of a variety of design methods, and because of his emphasis on merchant ships, this work cannot be ignored in the present study.

For detailed information on masting and rigging, two publications excel. David Steel's *The Elements and Practice of Rigging and Seamanship (*1794), and Darcy Lever's *The Young Sea Officers Sheet Anchor* ... (1808) provide an incredible amount of detail. Among the topics discussed are determination of masting and spar proportions, sizes and types of ropes and blocks required, detailed illustrations of standing and running rigging, and sail types and materials.

Two additional contemporary publications deserve mention; even though they are not treatises on shipbuilding, they provide useful overviews of the progress of naval architecture and shipbuilding throughout the history of Britain. They are John Charnock's *An History of Marine Architecture* (1800-1802) and John Fincham's *A History of Naval Architecture* (1851).

Note: The treatises and publications relating to eighteenth-century naval architecture, shipbuilding and rigging are discussed further in Appendix B.

General Theories Common to the Treatises

Fincham (1851:xlii) stated that mathematical theories on shipbuilding were virtually unknown in England until the late eighteenth century. Although his statement is essentially correct, it must be acknowledged that even in the seventeenth century English shipwrights followed a set of widely-accepted design principles as described by Bushnell (1664), Deane (1670) and others. However, those early principles were based almost wholly upon tradition, and involved the use of proportions and simple drafting techniques rather than theoretical design. Even Chapman's *Treatise* of 1775 presented mathematical design parameters based primarily on observation and limited experimentation, rather than upon a purely theoretical foundation. This seems to be generally true for all contemporary treatises, even those of the more "theoretical" French authors.

As discussed in the previous chapter, it is clear from the treatises that well before the end of the seventeenth century English ships had attained a very "modern" form; that is, the majority of both warships and merchant vessels exhibited certain basic and common characteristics that would endure throughout the 1600s and beyond. Those included a hull that was wide in proportion to its length; relatively high sides with significant tumblehome; prominent superstructure, or "castles," at bow and stern; three masts, square rigged on the fore- and mainmast, with a lateen sail on the after, or mizenmast (Davis 1962; Lavery 1988; Parry 1971; Unger 1978). It was during this period that warship and merchant ship designs began to diverge, becoming distinctly different vessel types by the eighteenth century. Of special significance to this study, the treatises discussed above do not appear to identify the emergence of any new English vessel types during the eighteenth century.

However, the treatises must form the foundation for an analysis of the state of ship design and shipbuilding during the eighteenth century. Chapman, in his *Treatise on Shipbuilding* (Ingram 1820:xiii),[11] specifies the following criteria for design of a proper merchant ship:

> A merchant ship ought:
>
> 1. To be able to carry a great lading in proportion to its size.
> 2. To sail well by the wind, in order to beat easily off a coast where it may be embayed, and also to come about well in a hollow sea.
> 3. To work with a crew small in number in proportion to its cargo.
> 4. To be able to sail with a small quantity of ballast.

He then discusses the difficulties in satisfying all these criteria simultaneously, summarizing that, "... for a merchant ship, it is necessary to combine these qualities, so that it may have the most possible of each" (*Ibid.*).

Almost all the treatises propose similar design criteria and "trade-offs" among variables, and most develop general hull shapes using similar graphical and proportional criteria and techniques. The following section reviews those criteria and techniques, then attempts to develop general design characteristics of merchant ships from the late seventeenth to the early nineteenth century.

Merchant Vessel Design as Depicted in Treatises from the Late Seventeenth Century

As described above, contemporary documents on ship design, especially those of Chapman, provide a framework for identifying and analyzing eighteenth-century vessels. This section attempts to identify common design criteria and practices and analyses pertinent information gleaned from the above treatises.

The two most reliable English shipbuilding treatises from the seventeenth century (Bushnell 1664 and Deane 1670) seem to agree very closely on general aspects of ship design. Both begin by selecting the length of keel as the basic design parameter. Both recommend a maximum breadth of approximately one-third the keel length; both recommend a rake of stempost of three-fourths the beam and a rake of sternpost of approximately one-eighth the beam. Deane specifies a slightly broader beam for merchant ships versus warships.

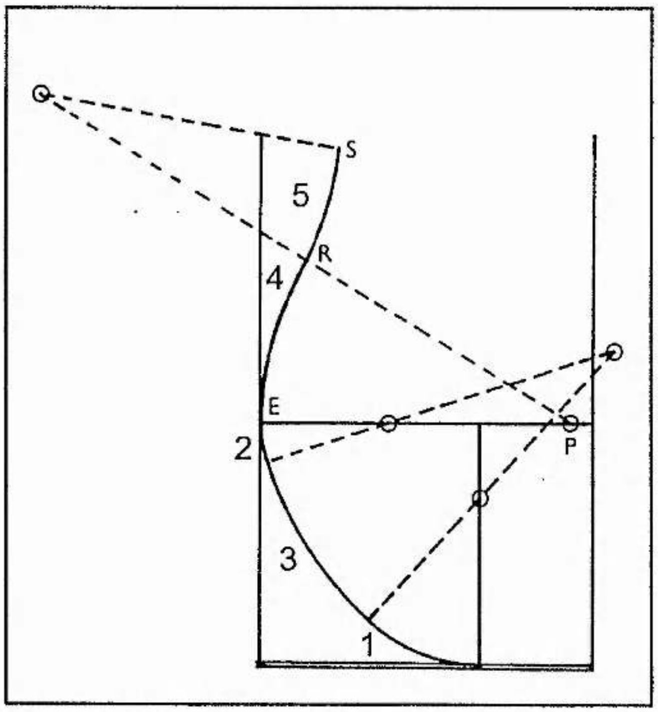
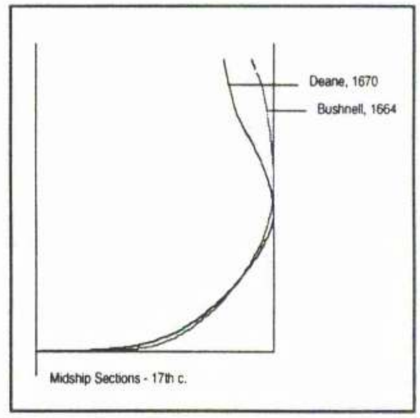


Figure 3.1. Deane's graphical method of constructing a midship section with five sweeps (1670).

From those basic parameters both treatises describe the construction of profiles, with stem and stern posts, wales, rising lines, etc.; then they construct midship sections with five "sweeps," all arcs of circles, as follows (Figure 3.1): floor (1), lower breadth (2), reconciling (3), toptimber (4), and hollow for toptimber (5). Bushnell specifies a slightly longer floor than Deane (0.40 x maximum breadth, versus 0.33). Bushnell specifies a rise of floor of one inch per foot of the half-breadth of the

Figure 3.2. A comparison of profiles of midship sections proposed by Bushnell (1664) and Deane (1670).



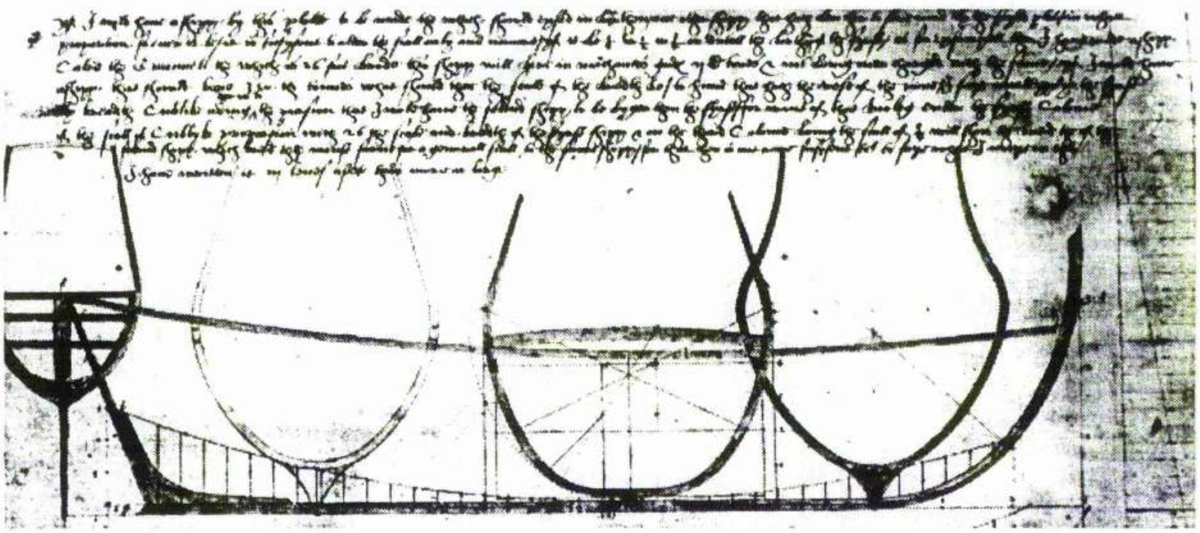


Figure 3.3. Profile of a ship from "Fragments of Ancient English Shipwrightery," late 16th century, showing body sections (attributed to M. Baker, 1585, Pepys Library, Magdalene College, Cambridge)

floor; Deane fails to mention the rise of floor, but his drawings clearly show a slight rise, comparable to that of Bushnell. The resulting midship frames (Figure 3.2) show the similarity of the two methodologies.

The completed plans in both treatises are similar to each other and are surprisingly comparable in appearance to eighteenth-century designs. The high castles, fore and aft, so conspicuous on vessels from the early seventeenth century, have been reduced, and the rake of the stem has been somewhat diminished. Possibly even more surprising, the general shapes of the hulls, particularly the midship sections, shown on the Bushnell and Deane drafts, are not unlike those depicted in several plans from Matthew Baker's drafts of *ca.* 1585 (Figure 3.3).

In order to establish a baseline for this study with which to compare later designs, data sheets were completed for the merchant vessel *Susan Constant*, 1605 (as reconstructed by Lavery 1988) and for Deane's design of the third rate warship *Resolution* of 1667 (as illustrated in Lavery 1981:124). Key dimensions and attributes are summarized in the following table:

Table 3.1
Attributes of Two Seventeenth-Century Vessels

Attribute	*Susan Constant*, 1605	HMS *Resolution* 1667
Length	76' 6"	156' 0"
Breadth	23' 1"	39' 2"
Draft	9' 0"	17' 2"
Tonnage	120 tons	1083 tons
L/B	3.31	3.98
C_m	0.797	0.793
C_{lwl}	0.849	0.767
C_{ff}	0.523	0.458
C_{af}	0.407	0.277
C_{hf}	0.465	0.368

Table 3.1 will be more meaningful after comparison with the analyses of additional hulls; however, a comparison of the two sets of coefficients clearly indicates that the *Resolution*, a warship, has considerably finer lines than the merchant ship *Susan Constant*.

Merchant Vessel Design as Depicted in Treatises from the Early Eighteenth Century

For insight into ship design and shipbuilding in the early part of the eighteenth century we are fortunate to have the published works of William Sutherland. *The Ship-Builders Assistant*, published in 1711, is a practical and detailed treatise; six years later Sutherland published a second work, *Britain's Glory: or, Ship-Building Unvail'd*. Together, Sutherland's two works provide a very detailed description of ship design technology at the beginning of the eighteenth century, even though both are heavily slanted toward warships. In *The Ship-Builders Assistant*, Sutherland (1711:69-75) provides a detailed table of scantlings for a ship of approximately 500 tons, followed later in the book by complete proportions for the rigging of a three-masted ship (*Ibid.*:139-46). His plates illustrate vessels virtually identical in general shape to those of the earlier treatises; his body plans are formed by five sweeps of circles in the same manner as proposed by Bushnell and Deane four decades earlier. His body plans are fuller than those of Deane, but nearly identical to those drawn by Bushnell. It is clear from Sutherland's two books that in 1717 no fundamental change had taken place in the design of English ships.

Merchant Vessel Design as Depicted in Treatises from the Second Half of the Eighteenth Century

Ship design in the mid-eighteenth century is well documented by Mungo Murray's *A Treatise on Ship-building and Navigation* (1754), and *Supplement to the Treatise on Ship-building* (1765). These books are particularly significant because of their extensive design information and tables of proportions for twelve merchant ships ranging in size from 50 to 630 tons. Instead of constructing body plans with arcs of circles, Murray provides tables and instructions for generating body plans by plotting points on a series of diagonals, as shown in Figure 3.4. Information for constructing the diagonals and plotting the points is given in Murray's tables. Other tables provide the data necessary for developing a profile and rising and shear lines. Several of Murray's vessels were reconstructed from his published tables, revealing a series of hull forms that are, like the merchant ship shown in Figure 3.4, relatively full-bodied and exhibiting a rounder hull form than those produced from the earlier practice of sweeping arcs that intersect with a relatively flat floor. Murray's tables seem to have been determined from the measurement of actual vessels, rather than derived from some theoretical framework.

The vessels depicted in Murray and elsewhere from mid-century appear to exhibit a more full, round body shape and lower profile than those from the beginning of the century. However, no radical alterations in hull form are evident.

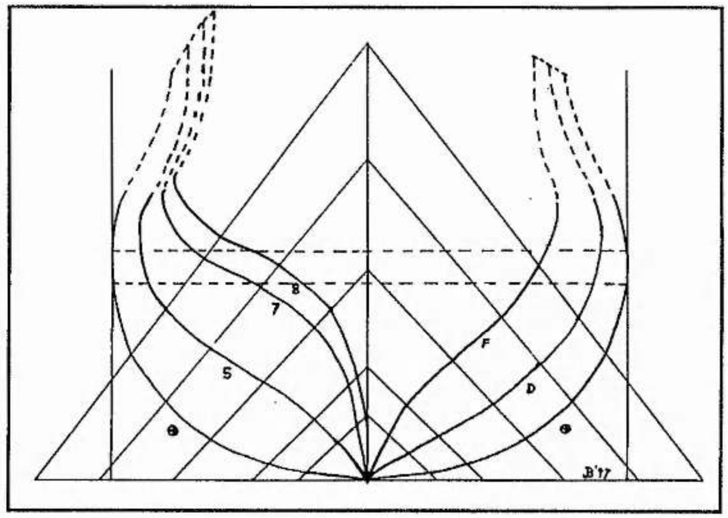


Figure 3.4. Body plan for the ship Thames, *340 tons, constructed from tables supplied in Mungo Murray's* Treatise on Ship-Building *of 1754 (J. Broadwater).*

A Closer Examination of the Vessels Depicted by Chapman

None of the early treatises on ship design and construction present as orderly a classification and description of merchant vessel types as does F. H. af Chapman's *Architectura Navalis Mercatoria* (1768) and the subsequent *Tractat om Skepps-Byggeriet* (1775). As previously stated, Chapman carefully presents detailed plans of different types or "classes" of merchant vessels in various sizes and with various rigs. Chapman's contribution to our knowledge of vessels of his day can only be fully appreciated after closely examining the ways he embellished each plan with details of upper works, deck furniture and layout, stern galleries, carvings, construction details and interior features.

Fredrik Henrik af Chapman was born in 1721, the son of a Yorkshireman who became a British naval officer before later making a career in the Royal Swedish Navy. Chapman grew up in and around dockyards and shipyards, and by the age of ten was producing incredibly detailed draughts of vessels he had visited (Harris 1989:20-21). In addition to his intimate exposure in Sweden to a wide variety of vessels—both Swedish and foreign—he also spent seven years in Britain, France and the Netherlands studying their shipbuilding theories and methods (*Ibid.*:21-24). His treatise and draughts represent the first attempt to approach shipbuilding from what would today be referred to as a "systems approach." In his preface to the *Tractat* Chapman states (Inman 1820:xii):

> Of [the principal good] qualities one part is at variance with another; it is necessary therefore to try so to unite theory and practice ... so that the sum of both may be a maximum.

Close analysis of Chapman's draughts revealed a very significant fact: there is no question that *all but a few of Chapman's draughts depict theoretical, rather than actual, vessels*. There are two principal reasons for reaching this conclusion. First, few of Chapman's vessels are identified by name; second, all of his vessels exhibit such a remarkable intra-class and inter-class regularity of hull form that there can be no question that most of the draughts are generic representations, based on Chapman's design preferences rather than upon actual extant vessels. When basic hull dimensions (length, breadth, depth and tonnage) are plotted for the vessels in each of Chapman's classes (Figure 3.5), the resulting curves are so smooth and regular that it is impossible to imagine the lines were taken from actual vessels. Also, in spite of a few interesting irregularities, the curves are smooth and consistent with Chapman's theoretical design formulae. These smooth curves are even more dramatic when examined alongside the irregular curves generated from draughts and hull remains of actual vessels, as presented in later chapters and in the appendices.

The most curious irregularity in the curves is caused by frigate draught number 9 (Figure 3.5a). Whereas the other nine draughts depict hull forms that decrease proportionally from largest (no. 1) to smallest (no. 10), the frigate in draught 9 is nearly two feet longer than that of draught 8, but has a lesser tonnage primarily because its depth is less. These measurements were checked against the draughts and verified to be correct. The reason for this anomaly can only be speculated, but it may be due to the fact that this relatively small frigate is rigged as a schooner, which Chapman may have treated differently.

These discoveries prompted further analysis of Chapman's draughts and produced more interesting surprises. In *Mercatoria* Chapman groups merchant vessels into five classes, based primarily on hull form (to which, following the lead of MacGregor (1988:29), this study added a sixth, the flyboat). In his *Tractat*, however, Chapman presents a table of formulae for the design of vessels of all classes (his "table No. 1"), a portion of which is reproduced below in Table 3.2. Significantly, in "table No. 1" (Inman 1820:208-209), he

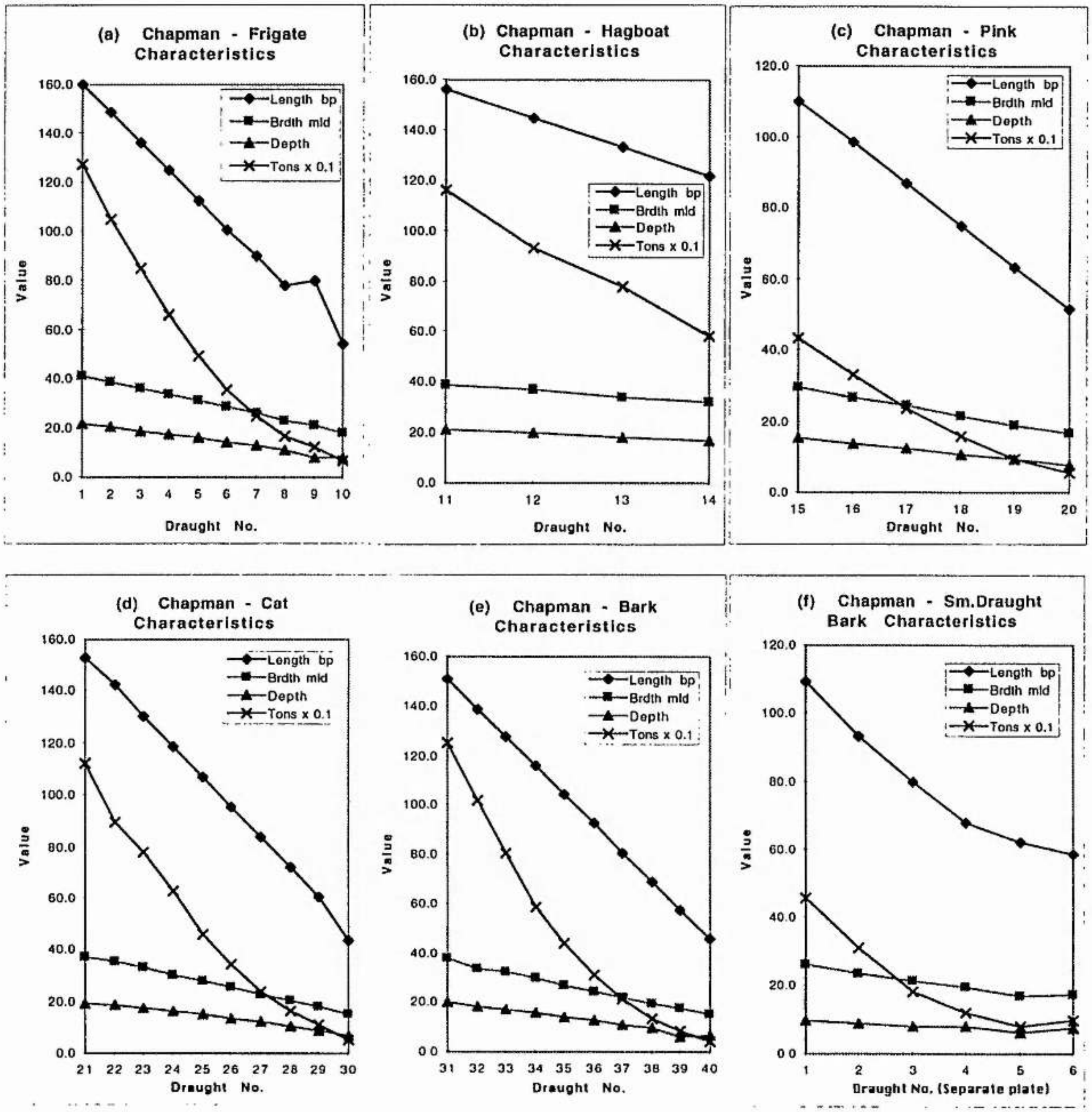


Figure 3.5. Graphs showing the relative dimensions for the various classes of merchant vessels, as described by F. H. af Chapman (1768).

has combined the five classes into three: frigates, heckboats (hagboats)/pinks and cats/barks .[12] To those he adds a fourth category: "flat-bottomed vessels, or vessels with a small draught of water." This is not a contradiction but, rather, appears to be an important element in Chapman's concept of vessel design—consideration of the purpose for which the vessel is intended. Chapman (*Ibid.*:83.84) describes the categories as follows:

1. Frigates "are to be navigated in seas where hostilities are to be apprehended [and so] should carry … artillery, and at the same time sail well …."

2. Barks and cats "have few or no guns; they are built solely for trade; and their object is to carry the greatest possible lading, and sail with the smallest possible number of men."

3. Heckboats or pinks "in regard to qualities, preserve a mean between [the first two categories."

4. Flat-bottomed vessels "have the same qualities with [barks and cats]; but not having so great a draught of water when laden they want less ballast."

Table 3.2
Portion of Vessel Design Table from Chapman (Inman 1820: 208)

Species of ship	Burthen in lasts reduced into cubic feet, reckoning 91 cubic feet for each last	Displacement in cubic feet to the outside of the timbers	Length from the perpendicular at the stem to that at the sternpost	Greatest breadth to the outside of the timbers	Distances of the load water-line from the upper edge of the rabbet of the keel, at the frame ⊕	Area of the midship section	Depth of the keel measured from the upper edge of the rabbet	Difference of draught of water
	P	D	x	. z	b	$\oplus$	k	d
Frigates	$D^{17/18}$	$P^{18/17}$	$\overline{56D^{1/3}}$	$\frac{x^{4/5}}{1{,}383}$	$\frac{x}{8{,}1}$	$\frac{1{,}705\,D}{x^{1+1/40}}$	$\frac{x^{2/5}}{4{,}64}$	$\frac{x^{1/4}}{23{,}3}$
Heckboats or Pinks	$D^{19/20}$	$P^{20/19}$	$\overline{54D^{1/3}}$	$\frac{x^{4/5}}{1{,}429}$	$\frac{x^{1-1/60}}{7{,}547}$	$\frac{1{,}729\,D}{x^{1+1/27}}$	$\frac{x^{3/7}}{5{,}66}$	$\frac{x^{2/3}}{17{,}5}$
Cats or Barks	$D^{21/22}$	$P^{22/21}$	$\overline{52D^{1/3}}$	$\frac{x^{4/5}}{1{,}476}$	$\frac{x^{1-1/30}}{7{,}032}$	$\frac{1{,}76\,D}{x^{1+1/20}}$	$\frac{x^{1/2}}{8{,}4}$	$\frac{x^{2/3}}{18{,}8}$
Flat-bottomed Vessels, or Vessels with a small draught of water	$1{,}07\,D^{21/22}$	$\frac{P^{22/21}}{1{,}07}$	$\overline{63D^{1/3}}$	$\frac{x^{4/5}}{1{,}6}$	$\frac{x^{1-1/10}}{6{,}436}$	$\frac{2{,}1\,D}{x^{1+1/10}}$	$\frac{x^{1/2}}{9{,}8}$	$\frac{x^{2/3}}{24}$

Chapman seems to be asserting that all merchant vessels (and warships?) can be placed into one of these four categories, and that although they may differ in overall appearance, the forms of their hulls will conform to the formulae presented in his table. Looking more closely at the table, it can be seen that of the fourteen parameters defined by formulae, none actually defines a specific hull form. Rather, the parameters are basic size (length, breadth, and depth), draught, tonnage and displacement, areas of the midship section and load waterline, and several parameters related to stability. In fact, Chapman's treatise does not discuss the development of a set of lines for any of his vessels; apparently he was content to provide readers with a varied set of draughts from which lines can be taken.

Chapman then provides a very clever and useful illustration, his Figure 32 (*Ibid.*:Plate 9), consisting of a series of parabolic curves that are graphical representations of the formulae given in the table.[13] From this illustration, Chapman states that one can "find immediately the properties of ships, proportioned according to table No. 1" (*Ibid.*:208-209).

To develop a thorough understanding of Chapman's formulae, his equations were used to derive design parameters for four of the frigates depicted in his draughts. The resulting values were then compared to data presented in the plates. In order to simplify analysis and to make the equations more useful, a spreadsheet was developed to calculate the value of various parameters at even increments of vessel length (between perpendiculars). The results are displayed graphically in Figure 3.6. To further simplify the presentation, only three parameters were graphed: burthen in Swedish lasts (P), maximum breadth (z) and load waterline (h), all in Swedish measurements. Figure 3.6 follows the same strategy developed by Chapman in his Figure 32 as a means of graphically deriving the various design parameters when the length of the vessel is given.

Figure 3.6 determines the parameters for four of Chapman's frigates, based on their length, in Swedish feet. As an example, frigate number 9 is 82 feet in length. By drawing a vertical line through that value on the x-axis, then drawing lines from the crossing points back to the y-axis, the desired values can easily be obtained without calculation. (For simplicity, some construction lines were omitted.) The derived values were then compared

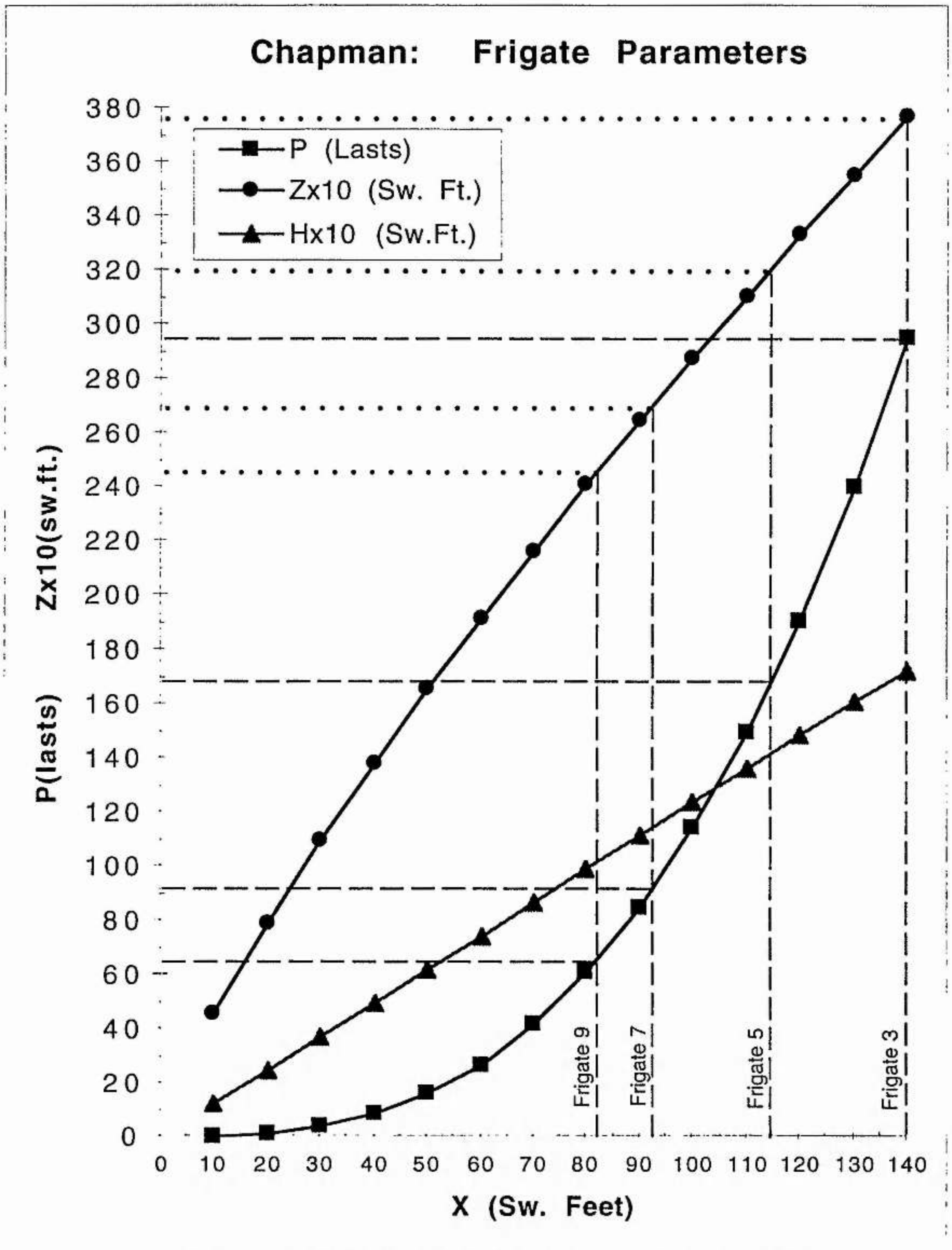


Figure 3.6. Graph of several frigate hull parameters calculated from the table by F. H. af Chapman (1768). This graphical method developed by the author can be used to determine Chapman's design parameters for a vessel of any given length. For simplicity, only three parameters for four frigates are plotted.

with those given in the key to the plates, and the results are presented in Table 3.3 and in Figure 3.7.

As the graph clearly indicates, frigate parameters for breadth (z) and draft (h) agree almost exactly between the values given in Chapman's plates and those derived from the graphs of the formulae. The values for burthen in lasts (P), however, differ noticeably. A similar examination was made of two barks and three cats, with the same results. For the barks and cats, the curves for tonnage (P) were smooth and nearly parallel, with the difference between them increasing slightly with the increase in hull length. The difference increased most rapidly with frigates, least with cats. Although no further tests were made, it is assumed that the other classes would produce similar results.

Chapman's original Swedish *Tractat* was consulted for possible transcription errors in Inman's English translation and the abbreviated text as presented in the 1971 Praeger publication,[14] but no errors were found in the formulae of interest. Fortunately, Chapman included a complete set of calculations for a bark or cat of 18,200 lasts burthen (*Ibid.*:85). Since his formulae require raising numbers to complex powers, Chapman made all his calculations through the use of logarithms. In his example he makes a mistake in deriving the logarithm of P raised to the 22/21 power, and this error is carried through the calculations.[15] At least one error was also made in converting to a logarithm value. However, the mistake results in an error of only about one percent or less and , thus, does not explain the discrepancies in the curves for tonnage. Using Chapman's formula, we see that $D = X^3/52$, and that P is directly proportional to D. A bit of manipulation revealed that a divisor of 49, instead of 52, would bring the curves into very close agreement, but this information does not shed light on the reason for the discrepancy. It should be noted that few in the eighteenth century even attempted to compute tonnage or displacement, and although Chapman's method was probably the most advanced of his time, it was later supplanted by a more accurate method (Fincham 1851:xlv).[16] Therefore, the discrepancies in the displacement curves may simply be an inherent error in the method.

Table 3.3
Comparison of Frigate Design Parameters

Chapman Plate	No.	Length x	From C's Plates z1	h1 x 10	P1	From C's Table z2	h2 x 10	P2
III	frigate 3	140.00	37.0	172.8	354.00	37.8	172	296
V	frigate 5	115.50	32.0	142.6	207.00	32.1	140	169
VI	frigate 7	92.25	26.7	113.9	105.00	27.0	117	91
VII	frigate 9	82.00	21.5	101.2	53.00	24.7	101	65

Notes: 1. See Figure 3.6 for the graphical source of the table data.
2. See Figure 3.7, below, for a graphical representation of the differences between the two methods.

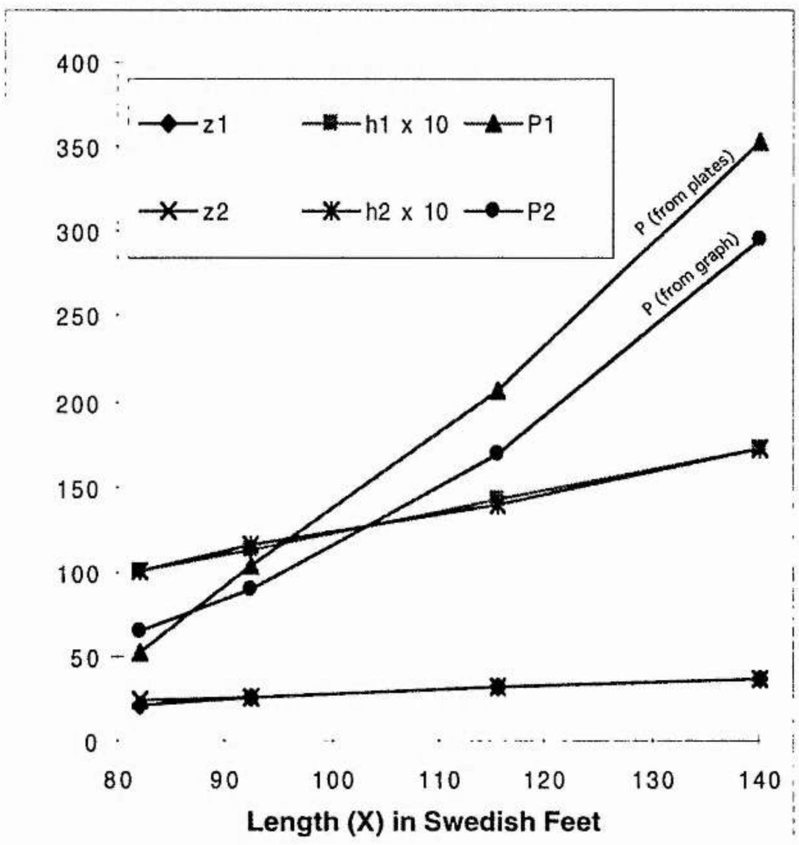


Figure 3.7. Graph comparing calculated parameters with those given in the keys to the plates in F. H. af Chapman (1768). It can be seen that parameters for breadth (z) and draft (h) match closely, while tons burthen (P) shows considerable variation.

The fact that the calculated curves, for the most part, are smooth and almost exactly in agreement with values lifted from the draughts is further evidence that most of Chapman's plates represent idealized—not actual—vessels. If that is the case, it is difficult to understand how the displacement discrepancies were created. Apparently Chapman designed and drafted his various vessels, then lifted or calculated the values given on the plates directly from the draughts. A further examination of Chapman's formulae, although outside the focus of this study, would be an interesting and worthwhile effort for someone with a thorough knowledge of the mathematics of naval architecture.

More pertinent to the present study are the details on vessel form and construction to be found in the *Tractat*. Chapman has included offset tables and scantling tables for a variety of merchant vessels. This information will be used in subsequent chapters and several appendices.

Merchant Vessel Design as Depicted in Treatises from the Last Quarter of the Eighteenth Century

To represent the state of merchant vessel design at the end of the eighteenth century, probably no better source exists than David Steel's *Elements of Naval Architecture*, published in 1805. In stating his purpose for publishing a treatise on naval architecture, Steel (1805:iii) asserts that

> ... although several works have already been published on the subject [of naval architecture], yet they were executed when the art was in its infant state; and when its fundamental principles were either misunderstood or very imperfectly known.

In spite of this condemnation of previous publications Steel presents few, if any, new theories or methodologies on ship design or shipbuilding. In fact, much of Steel's work seems to have been taken from the very treatises that he criticized. A particularly interesting example is Steel's suggestion (1805:122) to "let us divide the vessels of all nations into two classes: ... [small craft and oceangoing vessels]." This passage is suspiciously similar to one found in the preface to Chapman's *Tractat* (Inman 1820:vii). Steel (1805:iii[fn]) correctly states that the works of "the illustrious Chapman" had not been translated into English. However, a translation of the Tractat into French by Vial de Clarbois had been published in 1781 (Harris 1989:226) and was undoubtedly known to Steel. Steel proposes that body plans be constructed with five sweeps, in almost exactly the same manner as presented by Deane more than a century earlier. Little, if any, of his theory and methodology seems to offer strikingly new information. Possibly Steel's most valuable—and justifiable—contribution is that his book contains a complete picture of naval architecture and ship construction, presenting a wide range of information in a logical and clearly-written manner. He does not, however, cite any significant recent technological innovations in shipbuilding.

In his preface, Steel states that in the preparation of the treatise "actual workmen" were consulted and their methods compared by various experts "in order that the correct principles might be established, and the best practice explained" (1805:iv). Thus, one is tempted to conclude that Steel's methods resemble those presented in previous treatises because the technology of ship design had not, in fact, changed appreciably for more than a century. This possibility is discussed more fully in the next section.

Another useful source from the end of the century is the 1797 edition of *Encyclopaedia Britannica,* which includes a summary of naval architecture and shipbuilding (1797:373.434). The article, which quotes from a number of treatises, promotes the design of merchant ships that are broad with respect to length (a ratio of 1:3.14 is suggested) and with a depth of hold of half the breadth. The hull, it says, should be formed of flat floors to give good stowage, and the upper works should be kept as low as possible to provide good stability. The method presented for forming the midship section is, once again, to use five sweeps of circular arcs. Although this approach is identical to that proposed a century earlier, the hull forms presented in the *Encyclopaedia* (*Ibid.*:381-382) are, for the most part, more full and rounded.

John Charnock's three-volume *An History of Marine Architecture*, published during 1800-1802, is very comprehensive, chronicling the development of boats and ships from the earliest times, but he does not provide much insight into specific innovations in the merchant marine during the eighteenth century. Charnock (1800-1802III:202-203) does state that at the end of the eighteenth century "the commercial marine was by no means behind that of the state, in respect to the improvements introduced into it." However, few details are presented and his primary focus is on the navies of Europe and speculative innovations being proposed at the end of the century.

A Summary of Merchant Vessel Design as Depicted in Treatises from the Eighteenth Century

Although the treatises discussed above express different views and propose different methodologies for designing and building merchant ships, there are a number of common threads and much agreement on general criteria. All agree that there is no ideal hull form, but rather that a compromise must be made among various parameters in order to meet various needs. All list essentially the same design criteria: must carry sufficient cargo, must sail well, must be stable, etc. All agree that the design of a merchant vessel should be dictated by the intended purpose or trade for which the vessel will be employed; that is, a coastal trader that must negotiate inland tributaries and shallow waters should be much different than a deep-water merchantman or a fast packet. All present hull forms that are similar in very fundamental ways: all have straight keels, curved stems and nearly-vertical sternposts; all have the maximum breadth (midship bend) set somewhat forward of the midpoint of the distance between perpendiculars; all have similar curvatures in the sheer, or elevation, plan: height of toptimber line, height of breadth, rising lines, etc.; all present similar timber form and terminology, and suggest similar methods of construction.

It must be concluded from an examination of treatises from the late seventeenth century to the early nineteenth century that ship design and shipbuilding underwent important but subtle change, with no evidence of any fundamental leap in efficiency or effectiveness. However, let us now examine a source of information that provides us with documentation on actual vessels from the period of interest.

Admiralty Records Relating to Merchant Ships in the Transport Service

As discovered by Syrett (1970), Goldenberg (1976) and others, one of the most valuable and under-utilized sources of information on seventeenth- and eighteenth-century English merchant vessels is the rich and varied collection of Admiralty records relating to the procurement and operation of merchant vessels for the Royal Navy's transport and victualling services. When vessels were inspected and measured, complete inventories were generally made of their masts, yards, rigging, stores, equipment and furniture, with each item being assigned a monetary value. Descriptions, sometimes very detailed, were provided when reporting survey results.

The Admiralty records hint at trends in merchant vessel size and shape during the period of interest; however, since the Navy normally specified a minimum size and capacity for vessels to be leased, the resulting vessel descriptions cannot be taken to represent a full cross-section of merchant vessels in commercial service. Quite the contrary, the Royal Navy generally leased only transport vessels of 200 tons or greater (Syrett 1970:110), a size that was larger than the average merchant vessels of the period.[17]

Transport records for the period of the American War for Independence are particularly extensive. During the years 1776-1783, when Britain was engaged in wars in both Europe and North America, large numbers of merchant vessels were chartered for use as victuallers and transports. With trade in the American colonies and West Indies severely curtailed by the war, many British merchants were willing to charter their vessels to the Navy. The Navy Board chartered shipping under long-term agreements through ship brokers, underwriters and London merchants. Vessels obtained in this manner served as transports for war materials and troops (Syrett 1970:249-50). After 1779, the Navy Board also assumed responsibility for chartering victuallers (Baker 1971:241).

The mechanism for leasing vessels was the charter-party, described by David Steel in the 1792 edition of *The Ship-Master's Assistant and Owner's Manual*:

> The taking of a ship to freight is the hiring her of her master or owners; either in part or the whole, and either by the month, for an entire voyage, or by the ton: and the contract, reduced into writing, commonly called a charter-party, executed between the freighter and the person who lets the ship, must express the different particulars agreed on (Steel 1792:103).

So immense was the task of obtaining the necessary transport tonnage that Syrett (1970:5) asserted that during the American War " ... the Navy Board was undoubtedly the largest single operator of merchant ships under long-term time charters in the world." To support this assertion, Syrett pointed out that at any time during the war an average of 323.5 merchant ships, representing an average total tonnage of 96,637 tons, was under charter-party to the Navy Board. Merchant vessels chartered by the Navy Board were used as troop and horse transports, victuallers, and store ships. They carried a wide assortment of food, beverages, fuel, and military items, the latter including tents, clothing, cannon, small arms, powder and ammunition, as well as other supplies necessary for supporting a large fighting force on foreign soil.

Once a merchant vessel was offered to the Navy Board for use in the transport service it was thoroughly inspected, surveyed, measured and appraised, generally at a Royal Dockyard. If found acceptable the vessel was then chartered and fitted-out, as necessary, for its new service (*Ibid.*:100). It was the processing of leased merchant vessels which produced the most detailed records, many of which have been preserved at the Public Record Office, Kew, London.[18]

Inspection and appraisement records must be studied with caution, particularly with regard to the computation of tonnage, or carrying capacity. The Navy Board complained that Deptford surveyors "seldom find the Tonnage by measurement equal to what transports are tender'd for" (PRO, ADM 106/3404:106). This complaint was common, resulting in orders for all transports to be measured in Royal Dockyards whenever possible or to be remeasured at a Royal yard when the opportunity arose (PRO, ADM 106/2606, Sept. 26, 1781). Syrett (1970:110-113) accused the Navy Board of deliberately undervaluing merchant ship tonnage in order to reduce lease payments to the owners. This was done, Syrett alleged, by computing tonnage by a formula that yielded a value nearly twenty percent less than the tonnage claimed by the owner. This allegation suggests that the Navy Board was blatantly dishonest and the ship owners were gullible or submissive.

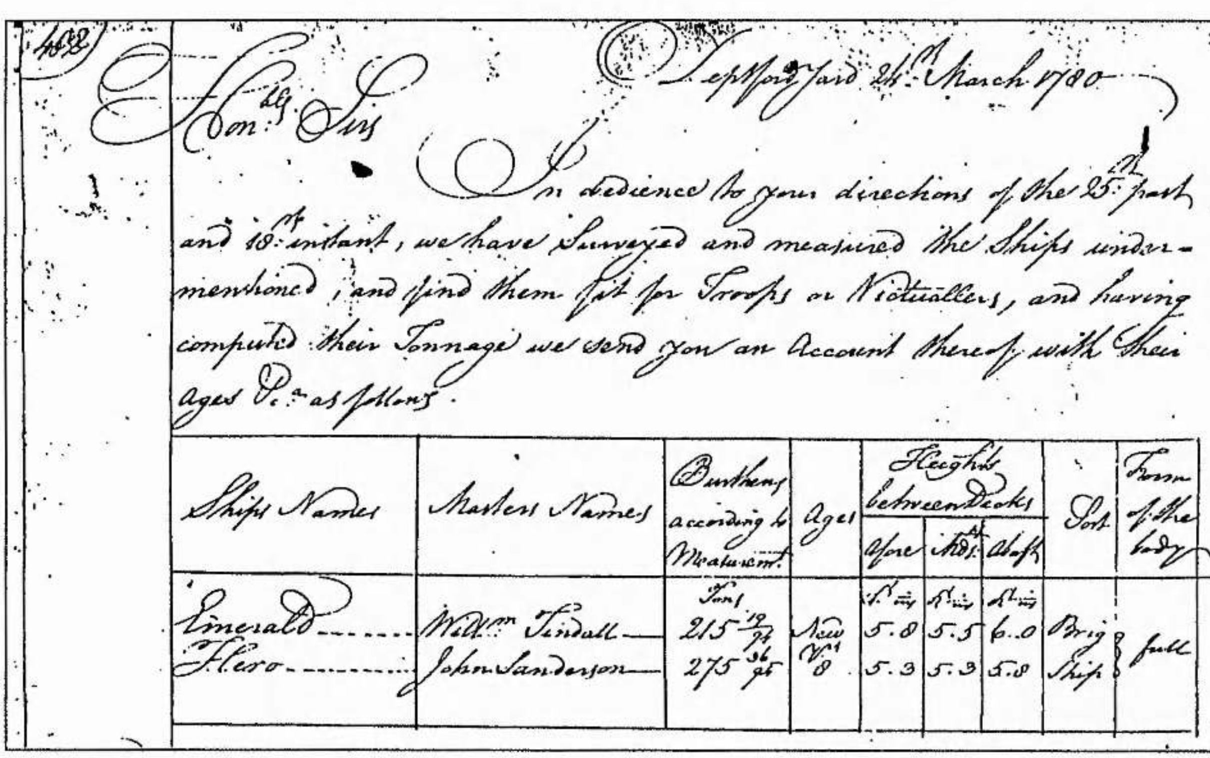
The Admiralty records (esp. ADM 106) clearly vindicate the Navy Board which, the records show, consistently applied the tonnage formula specified in British law. The misinterpretation is easily understood, however, since there are frequent references in eighteenth century documents to the confusion and lack of standardization regarding tonnage. There are numerous documents and treatises that verify that a standard formula, known as the Builder's Old Method, was widely used both by naval and commercial yards. The discrepancies generally arose because of the wide variation in methods used to obtain hull measurements for calculation. This study will attempt to standardize all tonnages. (See Appendix A for a more thorough discussion of tonnage calculations).[19]

Navy Board surveys and assessments help to form a general picture of typical merchant vessels (PRO, ADM 106/3318, 3402-4).[20] Of additional value is the fact that ship owners were responsible for offering their vessels completely ready for sea, so they seem generally to have leased their vessels with the same equipment and even the same crews as employed for commercial trade.[21] This continuity of crew and equipment provides an occasional overlap between naval and commercial records, thus offering a more complete picture.

Summaries of the survey reports were usually entered into the books at Deptford Dockyard, giving pertinent information on the surveyed vessels as well as the recommendations of the surveyors. Figure 3.8 shows a typical survey summary, this one for the new merchant vessels *Emerald*, 215 tons, and *Hero*, 275 tons. (This particular example was chosen because in October, 1781 the *Emerald*, serving as a naval transport, was scuttled at Yorktown, Virginia, as described in the next chapter.) Usually, a valuation of the hull, masts, yards, furniture and stores will be found with or near the entry giving the tonnage and basic measurements. Unfortunately, very few detailed survey reports have been located, although the few that survive are very helpful. A surprisingly large number of merchant ships actually had their lines taken off and detailed draughts prepared as part of their survey. Those plans, located at the National Maritime Museum, Greenwich, are discussed later in this chapter. A few valuations of the furniture and stores of transports are also to be found. A particularly detailed accounting was made in 1785 of the furniture and stores of five transports at Deptford Dockyard (PRO, ADM 49/125, Feb., 1785).

Many of the surveys provide interesting and useful details on the merchant vessel being examined. On November 22, 1773 the ship *Anson* was inspected at Deptford Yard (PRO, ADM 106/3402:119), with the following report:

> ... ye Anson being Dock'd we went on Saturday and inspected her bottom, The Sheathing having been taken off the garboard Seams, hood Ends, two strakes at the Floor heads, two at the Light Water Mark, and one between that and the Wales, We found by Boreing and trying at those places, that the seams were very firm, and the bottom perfectly sound. When the Sheathing is made good, and the Old new nail'd with the Other Works mention'd in our Report of the 13 Inst. all which are Carrying on, We are of Opinion she will be a Fit Ship for the Service.



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Deptford Yard 24th March 1780

Hon.ble Sirs

In obedience to your directions of the 25th past and 18th instant, we have Surveyed and measured the Ships undermentioned, and find them fit for Troops or Victuallers, and having computed their Tonnage we send you an Account thereof with their Ages &c.a as follows.

Ships Names	Masters Names	Burthen according to Measurement	Ages	Heights between Decks Afore	Midships	Abaft	Sort	Form of the body
		Tons		Ft In	Ft In	Ft In		
Emerald	Will.m Tindall	215 19/94	New	5.8	5.5	6.0	Brig	full
Hero	John Sanderson	275 36/94	Y.rs 8	5.3	5.3	5.8	Ship	full

Figure 3.8. Summary of survey reports dated 24 March, 1780 for the merchant vessels Emerald *and* Hero, *being surveyed as possible transports (PRO, ADM 106/3404:f.402).*

Surveys sometimes found the vessel wanting, as indicated by the Deptford survey report of 8 March, 1774 for the ship *Brudnell*, built at Shields in 1769 (PRO, ADM 106/3402:159):

> But we find her Upper Deck Beams of a very light Scantling, very sappy and vainey, ... the Beams also much streighten'd being only kneed with lodging knees.

The *Brudnel*'s carpenter, William Leakey, reported to the inspectors that "she was very leaky" and even after repairs "made Water" on her last passage, from "a leak in the Stern Post, which they could not find out ...." The forestep was reported rotten, and other problems were listed, but the master proposed to add hanging knees and make other preparations in order to fit her out as a transport (*Ibid.*).

Navy Board records generally list costs and valuations for transports and warships. On June 2, 1781 the Victualling Office reported that six ships with an aggregate tonnage of 1890 tons could be purchased and fitted for a total of approximately £25,000 for carrying provisions to North America (PRO, ADM C/642). That amounts to £13 4s 7p per ton for the purchase of six ships with an average size of 315 tons. At the time the transports were to be purchased, the Navy Board was paying 12s 9p per ton per month to lease transports (Syrett 1970:252). The rate for purchasing new transports can be compared with the cost for building HMS *Resistance*, a fifth rate warship of 44 guns, at a merchant yard in August, 1780 (ADM 106/3405:f.26):

Hull/Masts/Yards			**Furniture/Stores**		
Materials	Workmanship	Total	Materials	Workmanship	Total
£8000-0-0	5120-0-0	13,120-0-0	£5186-0-0	74-0-0	5260-0-0

The grand total cost for the *Resistance* was £18,380-0-0, which equates to £20 18s per ton, 63% more than the average cost of the transports. Considering the armament and additional equipment necessary for a warship, the differences in cost are probably reasonable.

For further comparison, December 1780 the Navy Board received quotes of £7547 from two private yards for the construction of a fireship of 433 tons (*Ibid.*:f.63). That equates to £17 18s per ton, but may not include armament and other equipment. On August 6, 1781 an estimate of £3266 was received for the construction of 200-ton brigs of 14 guns, an average of £16 6s per ton. This equates to an annual lease cost of approximately £2410 for a 315-ton transport. Syrett (1988:5-13) further demonstrated the usefulness of the Navy Board records in his paper on H.M. Storeship *Elephant*.

The Research Library at the National Maritime Museum, Greenwich, preserves additional Admiralty records dealing with the transport and victualling departments. For instance, a survey of the ship *General Clavson*, in New York, for possible use as a packet between New York and Halifax, lists all scantlings for the vessel (NMM, ADM 49/7:f.38). Although the *General Clavson* was American-built, it is useful for comparison with British-built vessels. This collection also contains such helpful documents as an original charter party, dated 25 July 1783, for the brig *Abercorne*, 181 tons, of London (NMM, ADM 49/2, Pt. 2:f.167). Manning information can be gleaned from this source as well. A letter from Lt. Tonken to the Navy Board stated that although charter parties required transports to carry 7 men per 100 tons, many of the masters insisted on carrying only six (*Ibid.*:f.229).

Admiralty records comprise virtually the only source of information on the performance of eighteenth-century merchant vessels. ADM 95 consists of volumes of large, printed forms on which have been entered data on the sailing qualities of naval vessels. A few of these reports preserve sailing information on transports and storeships. For the date October 3, 1744 there is an entry headed, "Observations of the Qualities of His Majesty's Ship the Deptford Storeship" (PRO, ADM 95/27:f.46). Among the notations are the following: "Carrys her Masts Upright, & her trim 7 or 8 Ins by the Stern"; "Steers, Tacks & Wears very well"; the ship could make 4 knots in a topgallant gale "if a fresh of Wind & Smooth Water." The report continues, listing speeds for various points of sail and wind strengths, concluding that the ship is very slow and "can spare Sail to none but Loaden Merchant Men."

Not all the storeships were so sluggish. The *Lenox*, tested on March 25, 1743, could go 10 knots, maximum, but "she rolls vigorously in trough & lies too very loathsome"

(*Ibid.*:f.12). Forty years later, on January 21, 1784 the storeship *Supply* was tested while loaded for service, having a draft of 15'10' forward and 18'0" aft (PRO, ADM 95/37:f.78). It was found to sail 4 knots in a topsail gale, behaving well, and 7 knots in a topsail gale, carrying a weather helm; it sailed best with the wind 2 points off the beam, where it made 8 knots and "rolls deep but very easy." *Supply* was found to be "a very weatherly Ship, nothing gets to windward of her." On April 6, 1784 the transport *Clinton* was found to reach a maximum speed of 11-12 knots, although it "Rolls very much." Of the *Clinton* it was also reported that "in little winds She Sails middling well—and in fresh Gales & off the Wind She Sails exceedingly well."

Undoubtedly the most famous merchant vessel to be found in the sailing reports is His Majesty's Bark *Endeavour*. The *Endeavour*'s sailing qualities were recorded in August of 1771, apparently after Cook's return from his first voyage of discovery (ADM 95/30, 3 August 1771). The entries on the standard printed form are purported to be in the hand of James Cook, himself (Beaglehole 1955:I:636). Her best sailing draft was entered at 13'6" fore, 13'10" aft, for Channel service, and 14'8"/15'0" for foreign service, with provisions for six months. In a topgallant gale, *Endeavour* was said to run about 5 knots and to steer well; in a topsail gale, 6 knots. The form reports that "Her best Sailing is with the Wind a point or two abaft the beam she will then run 7 or 8 Knots and carry a weather helm." Other responses included, "No Sea can hurt her laying Too under a Main Sail or Mizon ballanc'd," and "She is a good Roader and Careens easy and without the least danger." However, in answer to the querry about the height of her lowest gunport when fully loaded for foreign service, the answer was "Under water" (ADM 95/30, 3 August 1771).

From the few examples preserved in ADM 95 it is tempting to suggest that transports and storeships improved in speed in the second half of the eighteenth century. Further examination of the sailing reports might produce a few more transport sailing reports but will not yield a sufficient number for valid statistical analysis. Any such study must also examine the tested vessels to determine if they were purchased merchant vessels or were actually transports, storeships and victuallers constructed to Navy Board specifications.

The *Supply* above, for instance, may be the storeship *Supply*, 175 tons, built in 1759 in a private yard on the Thames under Admiralty contract (NMM, Navy Progress Book, Vol. 5: Nos. 525 and 527).[22]

Summary

A total of 37 vessels surveyed at Deptford Dockyard during the two years between February, 1773 and February, 1775 were tabulated and analyzed. As seen in Table 3.4 below, most of the surveyed vessels were large, with an average size of 326 tons. The only vessel below 177 tons was an 83-ton tender. The average age was a surprisingly-high ten years. In almost all cases, the height between decks exceeded the Navy Board's stated minimum of five feet. The data in Table 3.4 can be compared to those from the sources described in the remaining sections of this chapter. (Note: details on the vessels surveyed at Deptford can be found in Appendix C).

TABLE 3.4
DATA FROM VESSELS SURVEYED AT DEPTFORD, 1773.1775
(FROM PRO, ADM 106/3402)

	Tonnage	Age	Ht.dks.m'shp
Average	326	10.1	5.6
Median	311	10.0	5.5
Greatest	693	27.0	6.9
Least	83	0.5	4.7

As mentioned above, the Navy normally specified a minimum size of 200 tons for vessels to be leased for transports and victuallers; therefore the transport surveys in ADM 106 describe vessels that are essentially double the size of the average merchant vessel. The Navy Board also sought vessels with full lower decks, good height between decks, sheathed hulls, good condition, and other desirable features not necessarily common to all merchant ships. For these reasons, the Admiralty records should be used with caution when attempting to develop an accurate picture of all eighteenth-century merchant vessels. Nevertheless, the Admiralty records contain much untapped transport information that will reward researchers for many years to come.

Port Records and Registers Relating to Merchant Shipping

During the present study a surprising number of public records relating to merchant sailing ships was located in repositories in Great Britain. Many of these records resulted from the Registry Act of 1786 while others were generated by merchants who collaborated to provide insurance for their vessels and cargo.

Customs House Port Registers

Port records and vessel information dating to before the late eighteenth century are scarce. Although scattered fragments of earlier information can be found, they are not sufficient to permit a detailed comparative study. An act of 1696 called for the registration of English vessels engaged in trade with the colonies, but few such records survive (7 & 8 William III cap.18; Jarvis 1972:42-3). The Registry Act of 1786 was of great benefit to researchers since it specified the compulsory registration of all British vessels of 15 tons or more, to provide for "the further increase and encouragement of shipping and navigation" (26 George III cap.60). In 1786, in response to the Registry Act, all British customs houses began maintaining registers describing British-owned vessels belonging to their port. All information was recorded in register-books at the individual ports and fair copies were forwarded to the London Customs House on a regular basis, where they formed a massive

Table 3.5
Vessel Data Listed in Port Registers

Registration Number
Where and When Registered
Owners, with their Residence and Occupation;
  Distinguishing Subscribers from Non-subscribers
Ship or Vessel's Name
Of What Place
Master's Name
When and Where Built, or (if a Prize) made free;
  with Circumstances of Capture, and
Date of Condemnation
Name and Employment of the Surveying Officer
Whether British, Foreign, or British Plantation Built
Number of Decks
Number of Masts
Ship's extreme Length Aloft
Ship's extreme Breadth, at the Broadest Part,
  Distinguishing Whether Taken Above or Below
  the Main Wales
Heighth between Decks
Depth of Hold
Tons Burthen
Kind of Vessel
Type of Stern
Whether any or no Gallery
Kind of Head

compilation known as the "register-general" Craig and Jarvis 1967:xxxi). Unfortunately, the London Customs House was destroyed by fire in 1666, 1714 and 1814; the entire register-general was consumed in the fire of 1814 (*Ibid.*), thus obliterating all eighteenth-century registers. In approximately 100 individual ports of registry, however, at least some of the registers survive. Surviving port register-books list the vessels belonging to British ports from 1786 onwards, including vessels built earlier but still in service in that year. Therefore, the registers help to define merchant vessels during the second half of the eighteenth century. The data on each vessel is extensive, as indicated in Table 3.5.

The National Maritime Museum, Greenwich, conducted the Ports Registry Transcripts Project (PRTS) that transcribed port registry information onto preprinted sheets in order to preserve the data and make them more useful for research. The result was the transcription of port registry information from 60 British ports, from 1786 onwards. During the present study additional port registers, not included in the Greenwich project, were located and examined. Those were the registers for the northern outports of Carlisle, Newcastle, Scarborough, and Whitehaven. For analysis, data from a total of eight ports were examined, including the registers from Newcastle and Whitehaven, which were examined at local repositories.[23] The registers tabulated for analysis were:

Port Name	No. of Ships Sampled
London	78
Newcastle	133
Whitby	53
Whitehaven	109

In order to quantify these data in a meaningful fashion, a sampling from each register was entered into a computer database from which summaries, graphs and statistics were prepared.[24] All data were sampled from the registers for 1786-1787; sampling strategy was generally to sample every fifth British-built vessel in the register. Two years were sampled, instead of only 1786, since it appeared that the manner and order in which vessels were being entered into the registers might cause biases in the data. It was often two years before

TABLE 3.6
SUMMARY OF DATA FROM FOUR ENGLISH PORT REGISTRIES, 1786-87

LONDON REGISTRY

	Age	Length	Beam	Ht.Btwn Decks	Dpth.of Hold	Tonnage
Average	12.0	50.0	16.6	4.3	6.6	62
Median	11.5	47.2	16.3	4.1	6.5	47
Greatest	43	98.0	26.6	5.2	10.8	281
Least	0	24.5	9.3	3.3	3.0	7

NEWCASTLE REGISTRY

	Age	Length	Beam	Ht.btwn Decks	Depth of Hold	Tonnage
Average	12.3	87.7	24.6	4.7	11.0	217
Median	7.0	90.3	25.1	4.8	10.2	225
Greatest	69	114.0	30.3	6.3	16.4	423
Least	0	43.2	14.8	3.1	4.3	41

WHITBY REGISTRY

	Age	Length	Beam	Ht.Btwn Decks	Dpth.of Hold	Tonnage
Average	15.1	81.9	23.4	5.1	7.8	210
Median	10.5	92.1	25.7	4.9	7.9	246
Greatest	71	110.3	30.9	6.8	11.8	409
Least	0	43.5	14.4	2.1	4.4	42

WHITEHAVEN REGISTRY

	Age	Length	Beam	Ht.btwn Decks	Depth of Hold	Tonnage
Average	13.8	67.4	21.2	5.2	12.3	126
Median	12.5	68.6	21.8	5.2	12.7	129
Greatest	48	98.4	27.6	5.5	18.8	300
Least	0	34.2	10.9	4.9	6.2	16

NOTE: Data comprised of samples of the registers during 1786-1787. See Appendix C for a more detailed analysis.

a particular vessel appeared on the register, even though it might appear annually after that. Since the registries list all vessels owned in a particular port, this study excluded foreign-built and "Plantation-built" vessels. The results are summarized in Table 3.6.

The London Registry revealed that the vessels registered in that port in the early years were very small, mostly local barges and lighters, with only a few large ships. Of the sample examined (approximately 20 percent of the first two years), the largest vessel registered was 281 tons, and the median tonnage was only 47. This result was surprising, since private shipyards in the Thames area were building some of the largest merchantmen and East India Company ships during this period. According to Craig and Jarvis (1967:xxxv) London, in a departure from other ports, initiated *two* series of registries, one for vessels engaged in overseas trade, the other for coastwise trade. It appears that the register preserved in the PRTS archives is the coastwise book. All three outports examined for the present study registered larger vessels than London, with Newcastle having the largest average size, 217 tons, followed closely by Whitby, with an average of 210 tons. The average age of the registered vessels was similar for all ports, ranging from 12 to 15 years. Whitby

Table 3.7
Liverpool Vessels from Port Register, 1786,
Listed By Rig or Type of Vessel
(from Craig and Jarvis 1967:148)

Rig/Vessel	No.	Tons	Rig/Vessel	No.	Tons
Ship	70	18,181	Dogger	2	178
Barque	1	122	Flat	27	1,597
Snow	2	338	Sloop	26	1,441
Brig	--	--	Smack	2	87
Brigantine	50	6,323	Cutter	5	224
Galliot	6	770	Wherry	1	13
Galliot Flat	3	193	Boat	--	--
Schooner	6	344			
Polacre Ketch	--	--	**Totals:**	**201**	**29,811**

This table illustrates the interesting mix of terminology between rig (ship, snow, etc.) and vessel type (flat, wherry, etc.).

and Newcastle posted the oldest ships still in service, 71 and 69 years, respectively. More detail is given on the four registries in Appendix C.

A very detailed analysis of the Liverpool registry revealed that the average tonnage of British-built vessels registered in 1759 (the earliest year available) was 142 tons (*Ibid.*:145). The Liverpool register-books, consisting of 12 volumes covering the years 1786-1824 (when a new set of registry provisions was introduced) "constitute the largest and best preserved collection of such register-books in all British registry ..."(*Ibid.*:xxvi).

No tables were generated in the present study for the dimensions of the Liverpool vessels, but a very interesting listing of registered vessels by rig or type of vessel for 1786 provided the information shown in Table 3.7. Craig and Jarvis (1967) published an extensive set of tables that analyzed the Liverpool registry; however, their analysis ignored not only the primary dimensions of the vessels but also the very useful construction details preserved in the register-books. An examination of the first 64 English-built vessels in the registry reveal the following information: the three most common vessel types, making up 78 % of the sample, were the relatively-large ships and brigantines (19 and 15, respectively)[25] and the small coastal "flats" (comprising 16 entries in the sample). The remaining vessels were sloops (5), schooners (3), galliots (3), and one each snow, dogger and galliot flat. Twenty-six vessels had figureheads (almost exclusively ships and brigantines), while four had knee figureheads. Among the ships and brigantines, eight had quarter galleries and four had quarter badges. Virtually all of the vessels of all sizes (59) were recorded as having square sterns, with two having square tucks and two flats having round sterns; one flat had a "hackboat stern." Since almost all the vessels were said to have square sterns, this term must refer to the "square tuck" stern typical of vessels of this period, not the full square stern that, for the most part, went out of usage earlier in the century.

During the present study, time did not permit recording all construction details for all the ports; however, a cursory examination was made and observations noted. It was found that the port register-books for Newcastle, Whitby and Whitehaven listed a preponderance of square-sterned vessels, very few of which had figureheads, heads, galleries, quarter-galleries or quarter-badges. Most of the registered vessels were northeast built and the majority were probably typical "north-country colliers."

Jones's comprehensive history of the port of Whitby includes tables derived from that port's register. Of particular interest is her Table 2c (Jones 1982:46) which lists the place of build of vessels registered at Whitby, 1786-1815. The table indicates that of all Whitby-built vessels registered at Whitby during 1786-1815 the average size is 218 tons. When non-British vessels are removed from the table, the average tonnage for all British-built vessels registered at Whitby during those years is 184 tons.

The port registries that begin with the year 1786 offer a large volume of information on merchant vessels in almost all of the ports in Britain. For the purposes of the present study, however, the data do not shed much light on the actual construction and hull form of the vessels, other than the basic dimensions that have been summarized in Appendix C. The notation for vessel type seems to refer essentially to rig rather than hull form, and there is no indication of the strength or condition of the vessels. The best use of the port registers has been made by those conducting economic and social histories (Craig and Jarvis 1967; Jones 1982), but the registers also contribute to a more complete overall picture of British merchant ships.

Lloyd's Register of Shipping

Whereas the Customs House Port Registry, discussed above, was generated in response to a statutory requirement, *Lloyd's Register of Shipping* is a voluntary registry, originally established by an informal group of influential underwriters, shipping agents and ship owners who met at Lloyd's Coffee House in London (Brown 1973). The Customs House registers were maintained for such purposes as establishing title, origin and ownership, and for determining customs assessment rates, while *Lloyd's Register of Shipping* listed insured merchant vessels and classified them according to value and condition for marine insurance purposes. Vessels listed in the port registers do not necessarily appear in Lloyd's registry, especially in the case of small and private vessels. Conversely, *Lloyd's Register* listed all vessels, foreign and domestic, that had been inspected, classified and insured by Lloyd's surveyors. *Lloyd's Register*, therefore, contains information on some vessels of foreign registry which do not appear in the port registers, but excludes many small and uninsured vessels.

Table 3.8
Vessel Data Listed in Lloyd's Register

Owner(s)
Place of build
Date of build
Tonnage
Master
Rig
Ex names, where known
Destined voyage, port of trade
Port of registry
Classification (whether Lloyd's Register or other society)
Survey dates (of vessels classified by Lloyd's Register)
Other: No. decks and guns
Type wood in hull
Type sheathing

Although *Lloyd's* surveyors kept detailed survey records in the eighteenth century, those records apparently were not considered important enough to retain, or were destroyed in London's fires, since only a very few dating prior to 1800 have survived (Adams 1997:pers.comm.; *LR* 1992:pers.comm.). The register itself, however, contains very valuable information on eighteenth-century merchant ships. The first surviving register is dated 1764; the next is 1768 (a partial register); the *Register* is then complete for all years from 1776 onwards. The register lists entries for each year in alphabetical order by ships's names, and each entry contains the information shown in Table 3.8.[26]

The 1764 register, the earliest surviving volume, was sampled as follows: Beginning with the listings for the letter "A" every fifth British-built vessel was recorded on a computer until 15 vessels had been listed; then random pages were sampled for every fifth British-built vessel, adding five entries each time, until a total of 68 vessels had been listed. The 1764 register was sampled for a simple characterization of British merchant vessels in mid-century. A similar procedure was followed in sampling the register for the year 1800, to provide information on 85 registered vessels at the end of the century.[27] However, it was discovered after the data were recorded that "British" built included vessels built in all overseas possessions (Craig and Jarvis 1967:xxxi), so those entries were deleted, leaving 56 and 81 samples, respectively. Table 3.9 was derived from the resulting samples. (The data are given in more detail in Appendix C.) It can be seen that the average size of vessels

TABLE 3.9
A COMPARISTON OF DATA FROM *LLOYD'S REGISTER OF SHIPPING*, 1764 AND 1800

Lloyd's 1764	Tonnage	Age
Average	202	8
Median	168	8
Greatest	475	27
Least	30	1

Lloyd's 1800	Tonnage	Age
Average	205	11
Median	205	8
Greatest	467	46
Least	32	1

registered with *Lloyd's Register of Shipping* in 1764 was 202 tons and the average age was approximately eight years. By the year 1800 those figures were 205 tons and 11 years. Most of the vessels were in good condition, with many of the older vessels having received major overhauls. Most seemed to have only a single deck, with a lower deck only partially planked, providing maximum flexibility for the storage of a variety of cargoes. A majority of the vessels were sheathed, but only wood sheathing was available in 1764; even by 1800 only about 15 percent were sheathed in copper, a much superior, but relatively new and costly, method.

Further analysis of the *Lloyd's* data did not reveal any major changes over the last four decades of the century. The major changes over time noted from this very cursory sampling are a slight increase in average tonnage and age, a larger percentage of brigs and snows, a general increase in the size of two-masted vessels, an increasing number of copper-sheathed hulls, and probably a decrease in the armament of merchant ships. The average tonnage increased insignificantly from 202 to 205 tons (1.5 %) between 1764 and 1800 (Table 3.9), but the median size grew from 168 tons to 205 tons (22.0 %). Interestingly, the largest registered vessels in each sample were almost identical in size, as were the smallest.

The size of vessels registered in the northern outports is larger than the average size of the vessels registered by *Lloyd's*, suggesting there is probably an increase in the percentage and size of registered vessels built in the northern outports, but this small sample is not sufficient to make that statement with certainty.

While *Lloyd's Register of Shipping* is a very valuable general reference on eighteenth-century merchant vessels, it does not provide sufficient detail to be of much help to the present study; therefore, no further analysis was conducted. Of more value are the depictions of merchant vessels to be found in both two- and three-dimensional forms, as discussed in the following section.

Draughts, Models, Drawings and Paintings Relating to Merchant Shipping

Although merchant ships from the eighteenth century are not well represented among surviving documents, artwork and models, there are nevertheless enough examples to provide additional, and sometimes significant, details. The discussion below briefly describes the principal collections used in this study. More information is given in Appendix C.

National Maritime Museum

Draughts

The National Maritime Museum, Greenwich, England houses the most varied and extensive collection of draughts and sketches of British ships to be found, a small portion of which depict merchant ships. The draughts are grouped into related "boxes" or collections. Among those containing relevant plans and draughts of merchant vessels are the following (consult Appendix C for more information):

- **Early Admiralty Troopships, Packets, Etc.:** This box contains several excellent examples that illustrate the importance of Admiralty documents for the present study. For instance, there are three sheets of drawings for the brig *Industry*, 1765/1766, (NMM:Box 63: 6935-6937), which was being fitted out as a transport. The drawings include, in addition to complete lines draughts, deck and arrangement drawings that provide very detailed information on the construction and interior configuration of this merchant brig. The *Industry* is probably typical of the vessels selected by the Navy Board for the transport service, although at 221 $^{50}/_{94}$ tons and two-masted, it barely exceeds the minimum size requirement for transports. *Industry* is also representative of the North-country vessels of the latter half of the eighteenth century. As seen in Figure 3.9 the *Industry* is a beautifully simple and functional vessel, with few adornments. The deck and arrangements drawings probably show the brig with proposed alterations. Similarly, there are very complete draughts of the transports *Supply*, *Marquis of Granby* and other pertinent vessels. This is one of the most important collections for the present study.

- **Exploration and Survey Ships (NMM Box 66):** This box also contains some very useful and relevant draughts, including detailed lines, deck and arrangements draughts for Cook's *Resolution*, 1771, 461 $^{24}/_{94}$ tons (NMM:3435). There are also detailed plans of the *Raleigh*, 1771 (340 $^{8}/_{94}$ tons), that later became Cook's *Adventure*. Those are followed by the "as-fitted" draughts of *Adventure*, 1772. There are detailed draughts of the *Dutches [sic.] of Manchester*, 137 $^{11}/_{94}$ tons, bought by the Navy Board as a snow and converted to a brig by moving the mainmast aft.[28]

- **Hilhouse Collection and Charles Hill (NMM Code HHS):** The Hilhouse firm began purchasing shares in merchant vessels and privateers in the early eighteenth century and by 1748 had moved into shipbuilding (Hill c.1950:1-4). Throughout the remainder of the eighteenth century and beyond Hilhouse and Company continued to build merchant vessels, privateers and warships, many of them quite large. The National Maritime Museum houses a large collection of draughts, paintings and models from Hilhouse and Company, a few of which are eighteenth-century merchant vessels. Although most of the surviving plans and models are of large vessels, there are a few West Indiamen and

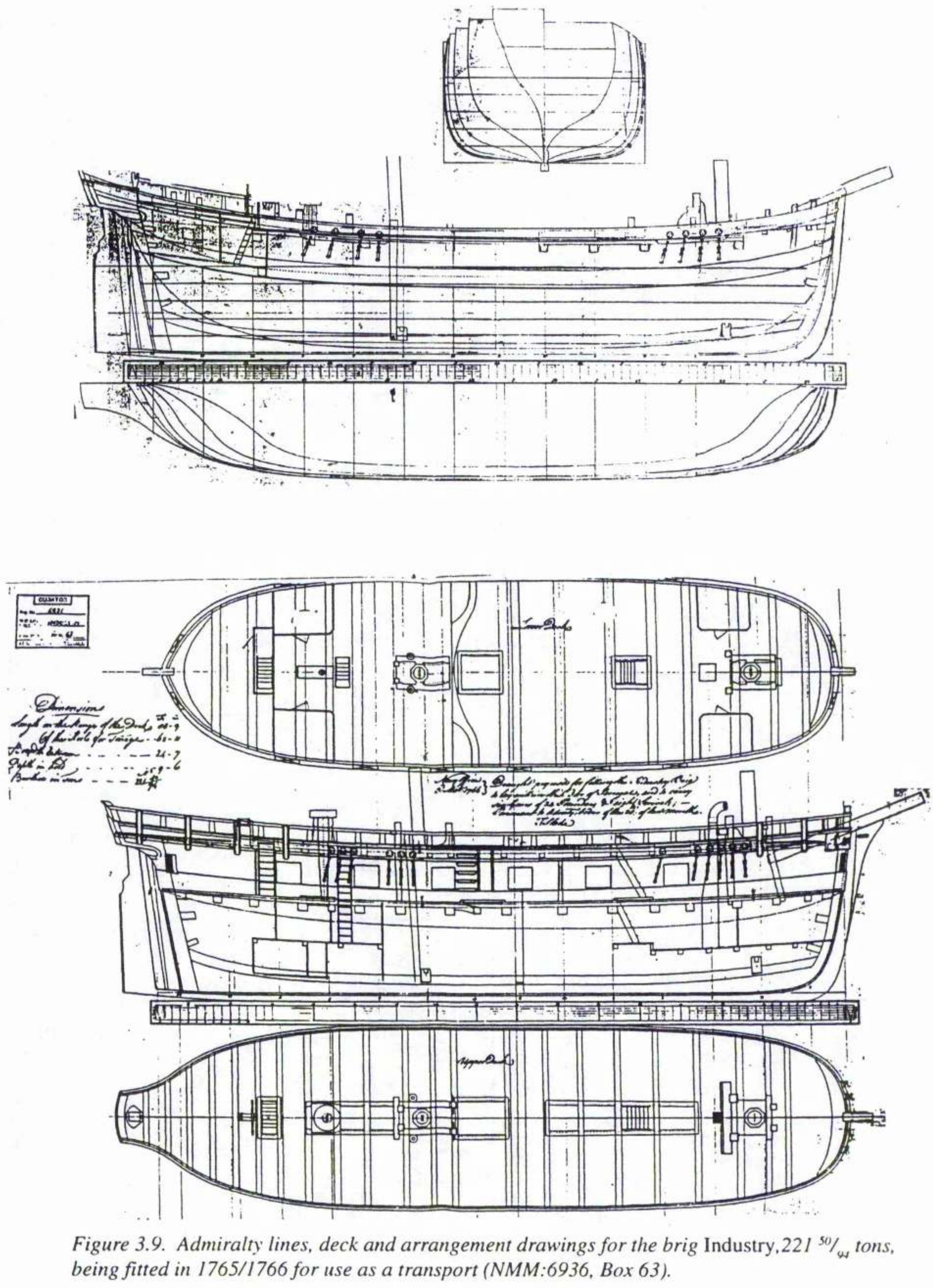


Figure 3.9. Admiralty lines, deck and arrangement drawings for the brig Industry, *221 $^{50}/_{94}$ tons, being fitted in 1765/1766 for use as a transport (NMM:6936, Box 63).*

other merchantmen of moderate size, including the half-model of the West Indiaman *Albion*, 350 tons, launched in 1782.

- **Whitby Collection (NMM Code WHY):** This is a small but very important group of plans consisting of Whitby-built merchant vessels and whalers from the 18th and 19th centuries. Greenwich has full-size copies, the originals of which reside at the Whitby Literary and Philosophical Society, Whitby, North Yorkshire. This collection is discussed in the Whitby section, below).[29]

Models

The National Maritime Museum collection contains contemporary models of several merchant vessels that are worth noting. One is a model of a vessel in frame, with only a few battens to support and connect the frames. The model probably depicts a collier brig of *ca*. 1820 (Stevens 1991:pers.comm.). The hull form is certainly representative of the bulk carriers that are the focus of the present study (Figure 3.10). The stem is plain and almost vertical; the floors are relatively flat, the bilge slack; the stern is typical of the En-

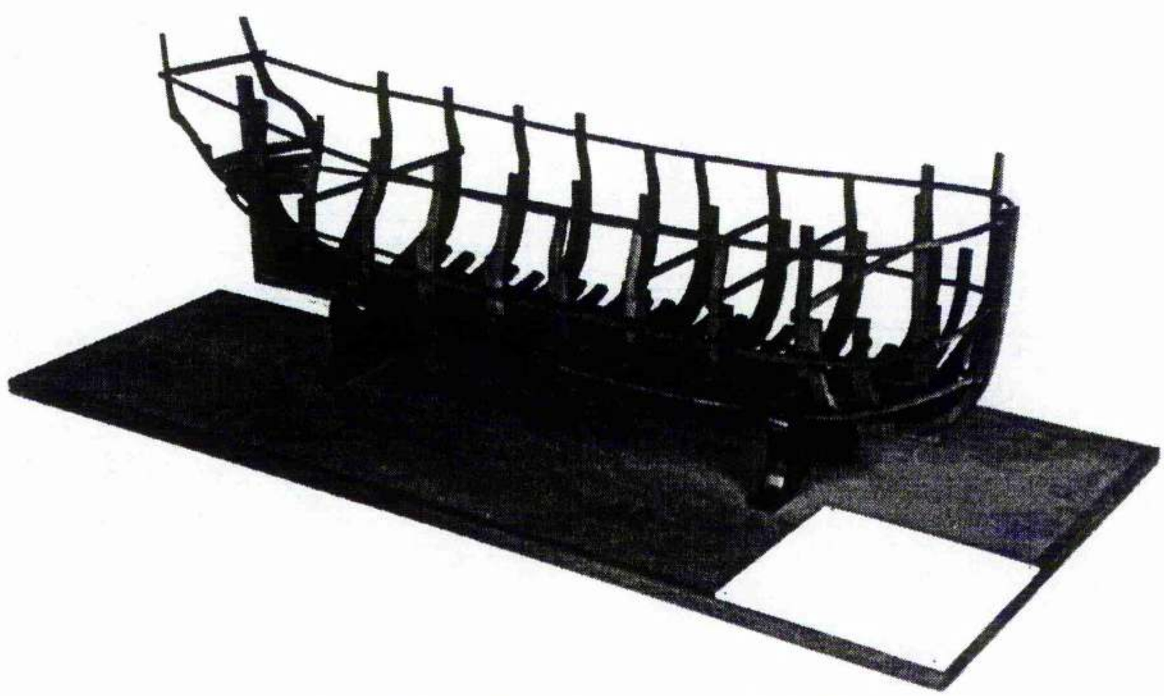


Figure 3.10. Model of a collier in frame, ca. 1820 (NMM:Neg.No. C2804). Courtesy National Maritime Museum, Greenwich.

glish modified square tuck. It seems reasonable to assume that this model is contemporary with those under study and that it accurately depicts the vessel after the hull-forming mold frames and filling floors had been erected. If so, the remaining futtocks were probably fitted by trimming them to conform to the hull shape formed by the mold frames, battens and planking. The model has its first futtocks set off the keel, a technique confirmed by documentary and archaeological data. (These characteristics are discussed more fully in later chapters.) The model was built at 1:32 scale, which converts to an actual vessel size of 64 feet by 20 feet, or 136 tons, burthen, a relatively small vessel that would almost certainly have stepped only two masts.

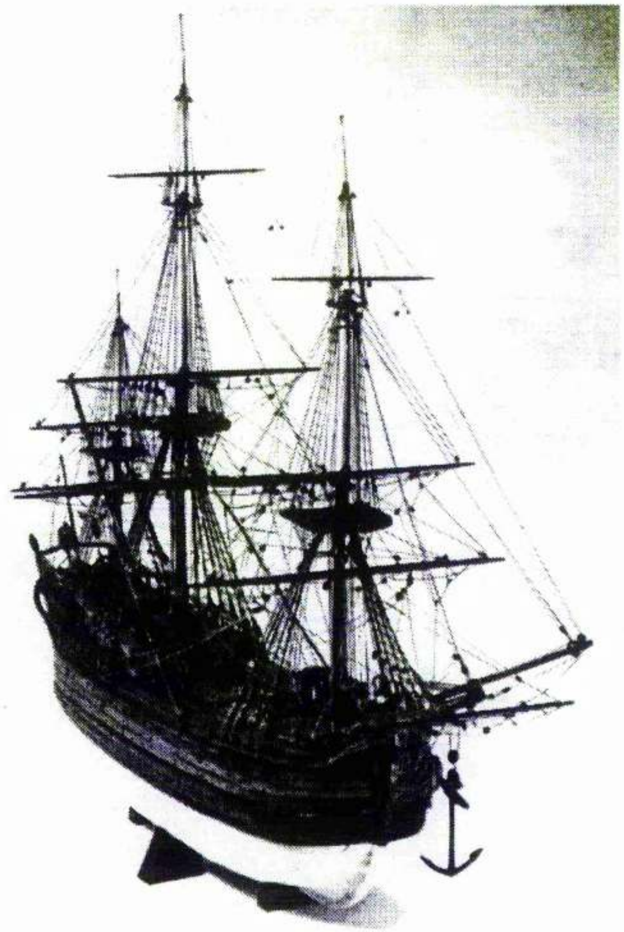


Figure 3.11. Model of a cat or barque, ca. 1750 (NMM:Neg.No. 6283). Courtesy National Maritime Museum, Greenwich.

The museum also owns an impressively large (1:24 scale) model of a cat or bark, with much of the original rigging intact, dating to the mid-eighteenth century (Figure 3.11). The model represents a barque-rigged vessel measuring 98' x 28.5 feet, which equates to approximately 423 tons. The stem is plain, the bows bluff and the stern is a round, or pink, stern.

Drawings and Paintings

The National Maritime Museum also possesses an extensive collection of contemporary drawings, sketches and paintings, some of which represent merchant ships. The collection can be manually searched using the Public Visual Index (PVI) made up of scores of notebooks containing data sheets and small photographs of each drawing or painting. Among the merchant ships in the collection is a painting of a very well appointed English snow, ca. 1750. This vessel has a long bowsprit crossing two yards, both bending sails. There is a fully developed head, with figurehead; the stern has a raised quarterdeck, quarter-galleries and a decorated stern (Figure 3.12). This is clearly a different type of merchant vessel from the bulk carriers and colliers typical of the northeast yards.

There are scores of other drawings and paintings in the PVI, and many were examined in detail for the present study. The majority were of merchant ships of moderate to large size, however, East Indiamen dominated the merchant ship paintings collection. MacGregor (1985) is the best source for merchant vessel illustrations, including some from the Greenwich collection.

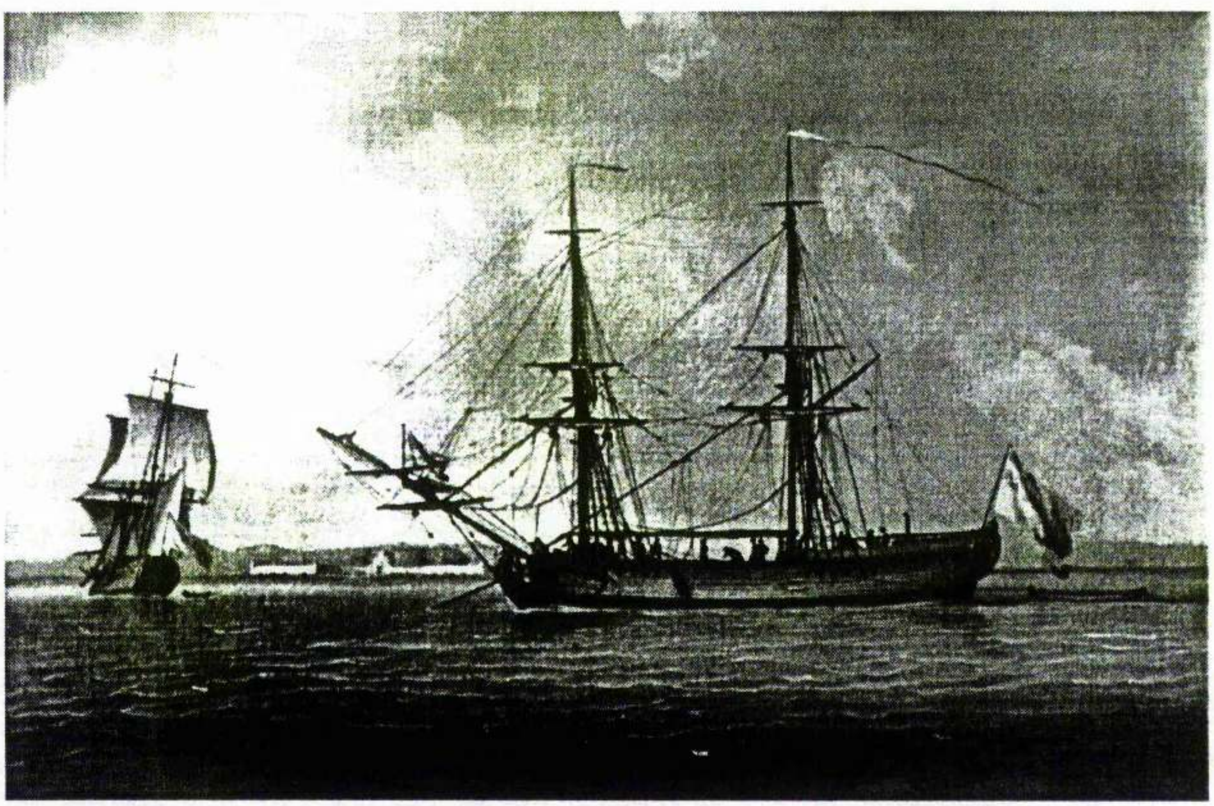


Figure 3.12. Painting of an English snow, ca. 1750, by Charles Brooking (NMM:Neg. No. 1426). Courtesy National Maritime Museum, Greenwich.

Newcastle Museum of Science and Engineering

The most interesting item at this museum, as far as the present study is concerned, is certainly a plank-on-frame model thought to depict a local-built collier dating to *ca.* 1800-1825 (NMSE No. 39721). Measurements taken from the model by curator Adrian Osler are as follows:

Length on deck -	82'9"
Keel (tread) -	64'0"
Beam (extreme) -	22'9"
Depth in hold -	10'0"

These dimensions yield a capacity of 175 tons.

The lines were to have been lifted from the model and draughts prepared but, as yet, this has not been done (Osler 1997:pers.comm.). However, the model displays the hull characteristics typically found in the north-country colliers for which Newcastle and the surrounding ports are so justly well known.

Whitby Museum and Whitby Literary and Philosophical Society Research Library

Smales Shipbuilding Records

The Whitby Literary and Philosophical Society Research Library, Whitby, North Yorkshire, possesses a small but extremely valuable collection of draughts of Whitby-built merchant vessels and whalers from the 18th and 19th centuries, apparently all donated by H. W. Smales, a direct descendent of the Smales Firm that operated a shipbuilding and masting firm in Whitby for two centuries.[30] Ships were being built in Whitby at least by the early seventeenth century, and the building of sailing ships continued until 1871, when the Smales Brothers launched the last, the barque *Monkshaven* (Walker 1971:11). During the middle of the eighteenth century Whiby rose to become one of the most important ship-building ports in England (Jones 1982).

The most valuable draught in the collection is undoubtedly the faded and smudged draught of a merchant vessel that supposedly dates to ca. 1770 (WLPS No.30, Figure 3.13). A researcher suggested it was the *Orient*, but another Whitby plan is identified as that of the

Orient and it is clearly a different vessel (WLPS No. 9). Another local researcher believes that the plans are of the ship *John and Mary* (or the *John and Jane*), 234 tons, built in 1770 by W. S. Chapman & Co. of Whitby. The museum has a well-made full-rigged model built from these lines. This study attempted to reconstruct the partially-obliterated scale and to extract the principal dimensions from the draught. The resulting measurements were 77'3" length between perpendiculars and 20'3" extreme breadth, which equates to 142 tons, considerably smaller than the *John and Mary*. In any case, the draught contains several interesting details, including two body sections, one showing the upper deck; an illustration of the stern windows and simple decoration; the gallows; and even an indication of the framing pattern. In fact, the profile identifies the "mold" frames that would have been erected to form the shape of the hull. Shown are a master couple (drawn as a double frame), three frames forward of the master couple, and five frames aft, for a total of nine stations that would have completely defined the vessel's form. This is exactly the number of frames in

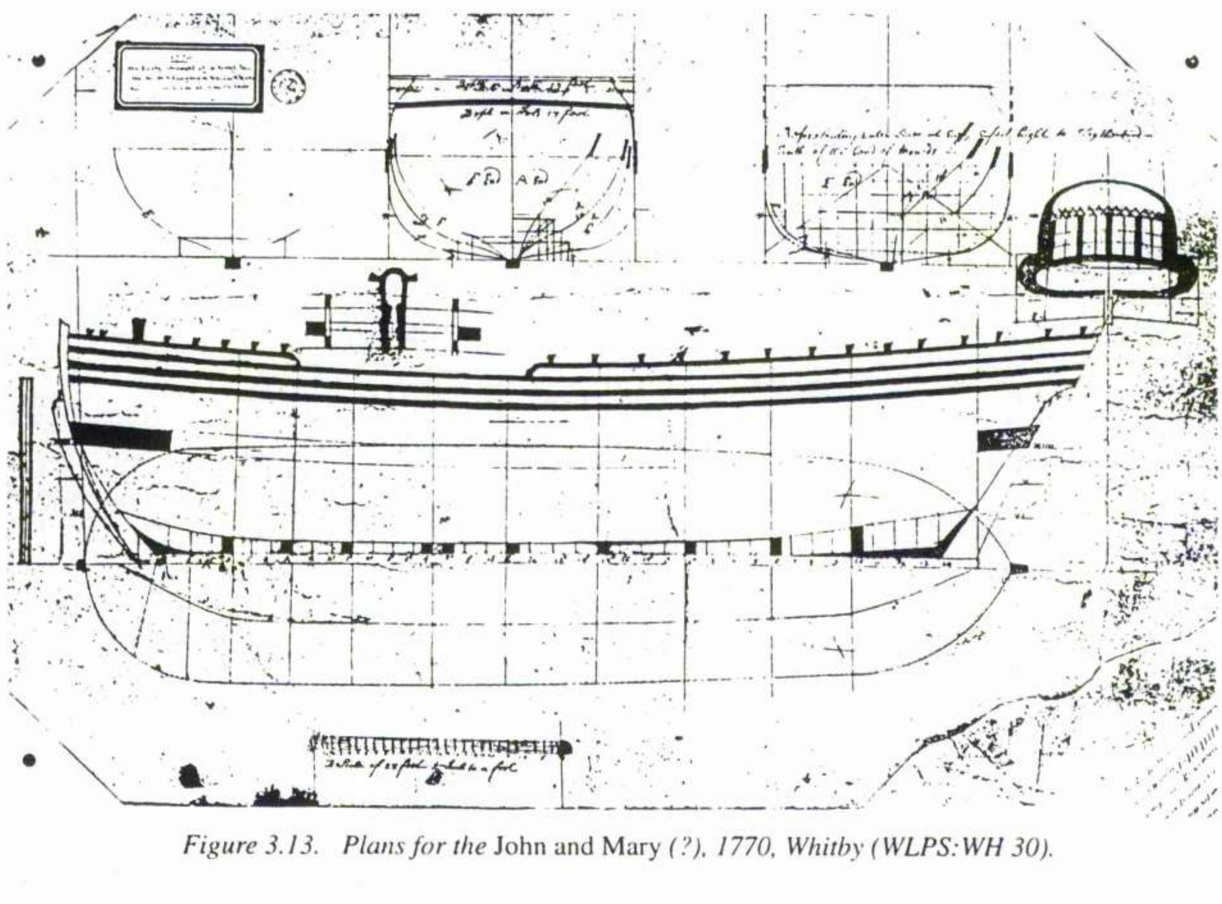


Figure 3.13. Plans for the John and Mary *(?), 1770, Whitby (WLPS:WH 30).*

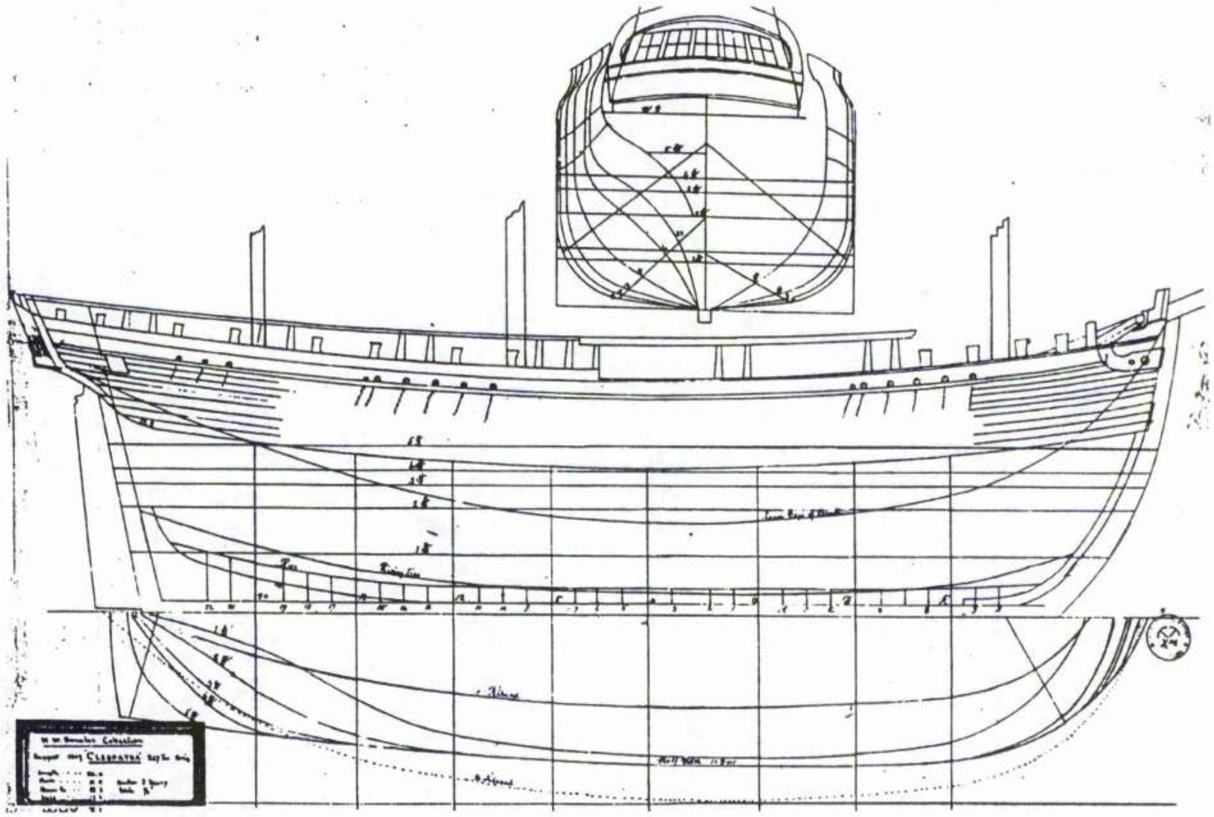


Figure 3.14. Lines Draughts for the ship Cleopatra, 1817, 267 tons, Whitby (WLPS:No. 31).

the collier model at the National Maritime Museum, not counting, of course, the bow cant frame because it is not a square frame (Figure 3.10). As stated in the discussion of the Greenwich model, the number and placement of these mold frames almost certainly indicates that they were the only ones erected to form the hull. This will be discussed more fully in later chapters.

Smales Masting Records

A remarkably detailed tabulation of merchant ship masting specifications was located in the former shipbuilding center of Whitby, at the Whitby Literary and Philosophical Society Research Library. This manuscript, dated 1959, was also compiled by H. W. Smales, who donated the ships's plans discussed above. In his introduction, Mr. Smales writes,

> Among my family papers there is an old parchment backed book labelled MASTING BOOK which gives particulars of the sizes of masts, spars, yards, blocks &c made by the firm for local built sailing ships over a period of some 200 years.

He goes on to say that the masting information "covers much the same period as the old Ship Draughts" which he previously donated to the library. Instead of photocopying the original masting book, Mr. Smales has apparently copied the data onto printed forms.[31] The Smales Firm of Whitby was engaged in shipbuilding and masting at least by the middle of the eighteenth century and continued until late in the nineteenth century, during which time the firm built scores of merchant vessels, many of which were employed in the coal trade.

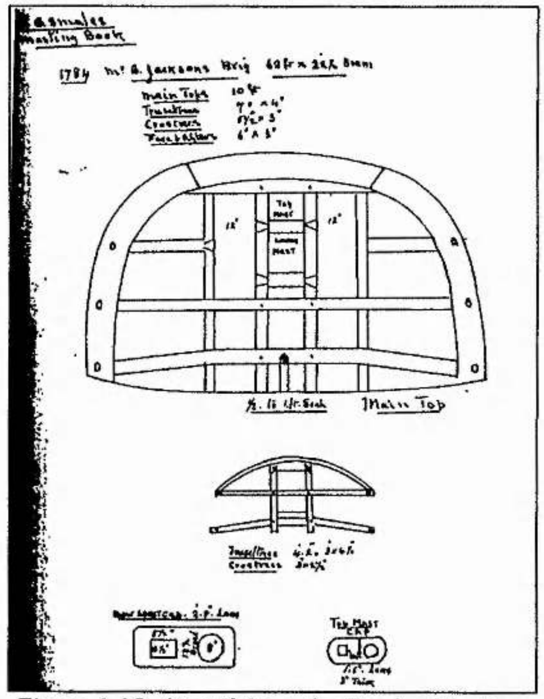


Figure 3.15. Detail from the Smales Masting Book (WLPS:Smales 1959:111).

The Smales Masting Book contains mast and yard dimensions for some 300 vessels. There are also a few tables and illustrations, including a sketch, with dimensions of the top, trestletrees and caps for the mainmast of "Mr. Jackson's brig" of 1784 (Figure 3.15). The first entry in the masting book is for the ship *Employment*, dated 1750; the last is a new iron barque, 473 tons, 1867. Mr. Smales notes that he had previously sent information on the masting of steam ships to the Whitby Museum.[32] The first brig appears in the book in 1765, the first "briganteen" in 1775, the first schooner in 1794 and the first snow in 1818.

Merseyside Maritime Museum

The Merseyside Maritime Museum in Liverpool has in its collection three models of particular interest. Of primary significance to this study, the museum displays probably the oldest half-model of a merchant vessel surviving in Great Britain, that of the collier barque *Liberty and Property* built in 1752 and owned at Whitby (Salisbury 1968:7; MMM No. 1963-286.7). The model is of the batten-on-frame, or "hawk's nest" style, and the scale is 5/16 inch to 1 foot. The frames are exposed below the lower wale, but above the wale the

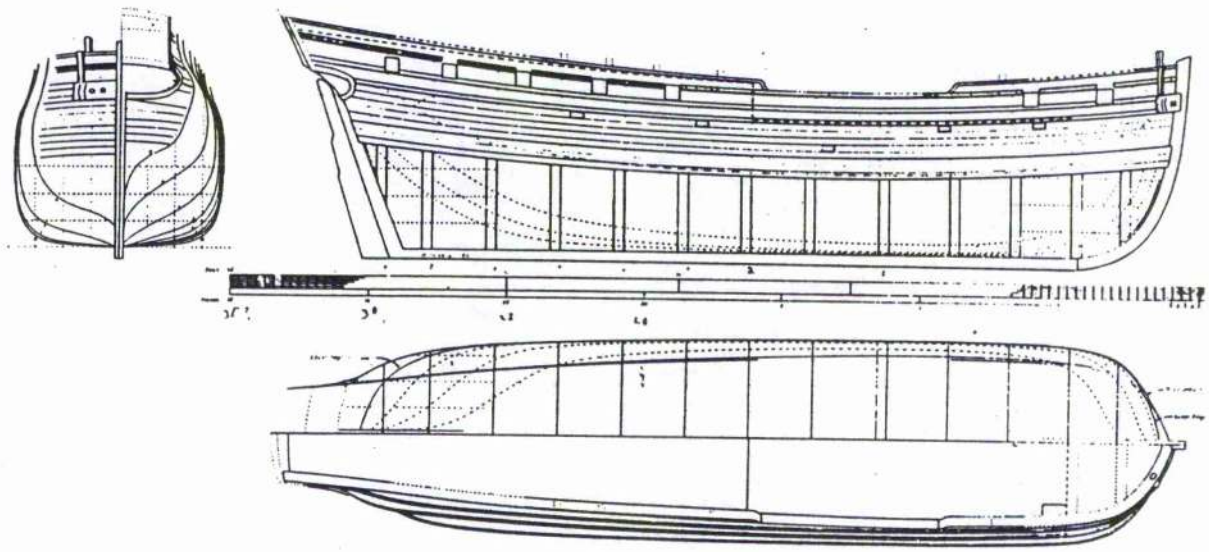


Figure 3.16. Lines draught of the collier barque Liberty and Property, *1752, lines taken by W. Salisbury from a contemporary half-model (1968:7-10).*

model has been planked, and gunports and railing are shown. This valuable model hangs high on a wall, to be admired from afar; fortunately, however, W. Salisbury took the lines off the model while it was housed in the Science Museum, South Kensington, and his lines were published in the Liverpool Bulletin in 1968 (*Ibid.*:10, Plates 1 and 2). The lines, Figure 3.16, depict a simple, unadorned hull very much like the "typical" north-country colliers of the latter half of the eighteenth century, except that the bow is not as bluff as many of those to follow. Salisbury (Ibid.:9) scaled the dimensions from the model and found that the dimensions of the vessel would have measured 92 feet on the length of the lower deck and 25 feet in breadth. Using the standard tonnage formula,[33] the vessel would have been rated at 306 tons, a realatively large vessel for its time. To further illustrate the *Liberty and Property*, the museum has on display a very well crafted full-rigged model (MMM No. 1942-39) based on the half-model. The third model is a contemporary model of an English merchant ship of the mid-eighteenth century (MMM No. 1963-286.1). The museum lists the measurements from this 1:48 scale model as follows: 130 feet length, by 32 feet breadth, by 16 feet depth. Using the standard tonnage formula, the ship would have been registered at 604 tons, a sizeable vessel indeed.

Private Documents Relating to British Merchant Shipping

Tindall Shipbuilding Records

William Tindale[34] was operating a shipyard in Scarborough before 1691 (Tindall 1927:10), and his descendents continued building ships until the yard closed in 1862. Thereafter, the family interests were concentrated in their shipping business (*Ibid.*:61). In 1771, at age 16, John Tindall took charge of the shipyard, where he built 110 ships, the one hundredth being christened *Centurion* (*Ibid.*).

Two private collections of papers and objects from the Tindall Shipbuilding firm of Scarborough came to light during the study. These collections belong to descendents of the family which operated the firm, and the current owners have very graciously permitted the

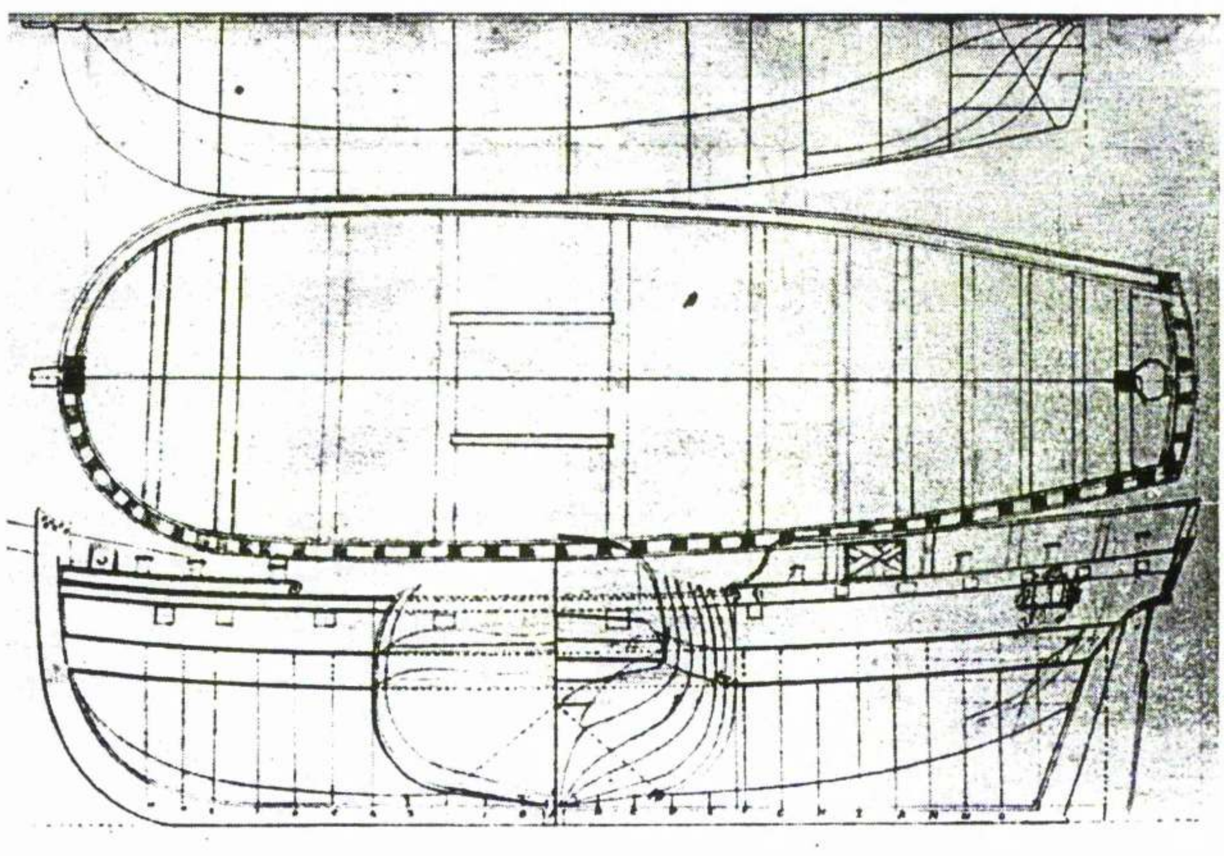


Figure 3.17. Lines Draughts for a proposed Tindall vessel, ca. 1780 (J.Tindall Collection).

author to examine and photocopy portions of the material. Company records in the possession of the current generation of the Tindall family were examined and analyzed. The collection includes numerous boxes of papers and letters; plans of one ship and a sketch of another; a fascinating log book from the Tindall ship *Emerald*, recounting its service as a transport in the American War; ivory scales and other drafting instruments; several oil paintings; and even a scale model that apparently represents a Tindall vessel from the early nineteenth century. If the firm built from detailed draughts and plans, then none seem to have survived. In fact there are amusing indications that the firm built vessels that had "evolved" over the years into a form that had proven durable and capacious and that most of the vessels maintained the same general design for many years. In a letter to his younger brother at the shipyard, Robert Tindall wrote from his ship at sea that he thought a new vessel should be built on the lines of the [illegible] with only slight modifications. To illustrate his point, he added a very well drawn profile of the desired vessel (Figure 3.17). The firm had a very deliberate system for employing the vessels they built and retained for their shipping business. Further examination of the Tindall papers would certainly prove worthwhile; however, for the present study, there was not sufficient detail to address the question of vessel improvements during the eighteenth century.

Miscellaneous Records

Scattered throughout the museums and galleries of the world is a myriad of paintings, drawings, letters and papers relating to eighteenth-century merchant shipping. Undoubtedly there are still more in private hands that may never be available to researchers. The small museums, libraries and historical societies of Great Britain, particularly those of the northern port towns, probably contain a wealth of pertinent data that have not yet come to light. In Whitby, for instance, there are undoubtedly additional papers from the Smales masting and shipbuilding enterprise, possibly stored among the possessions of H. W. Smales; the current Tindall descendents are unable to locate many of the valuable papers that, by family tradition, were passed down from previous generations. These may have been relegated to old trunks in Tindall attics or may await discovery in a small port town library. The present study attempted to locate and examine as many of these unknown private records as possible, with some success, but there is more to be found.

Summary

This general review of archival and documentary sources of information on English merchant vessels from the eighteenth century provides convincing evidence that a great deal of archival information is available—considerably more, in fact, than had generally been recognized. The contemporary treatises, especially, offer very detailed explanations lines draughts on the design and construction of merchant vessels. In addition, paintings, drawings and models offer additional evidence of the appearance and equipment of these vessels.

After reviewing available primary source material, however, one is still left to wonder just how rigorously those treatises and draughts were followed, especially in small private shipyards in remote outports. As has already been discussed, the authors of those treatises frequently expressed frustration at the inconsistency of shipbuilding and the disregard shown by shipwrights for even the most basic scientific principles. Several of the treatises define scantlings and specify construction and fastening instructions, but one must wonder how widely those instructions were known and how consistently they were followed. In short, how is one to determine how accurately the written records were represented in wood, iron and canvas.

The next part of this study attempts to answer that question by examining archaeological evidence from the vessels, themselves. This chapter has provided a basic framework from which to describe and analyze the evidence that has emerged from archaeological surveys and excavations over the past several decades.

Notes on Chapter 3

[1] Deane's "Doctrine of Naval Architecture" of 1670, although not published until the twentieth century, was known to shwrights in the late seventeenth century, and Edward Bushnell's work, *The Complete Shipwright*, first published in 1664, was in its third edition by 1670.

[2] A manuscript copy is available in the Research Library of The Mariners' Museum, Newport News, Virginia, and is now partially accessible via the Internet.

[3] Published for the first time by The Society for Naval Research in 1958 and 1921, respectively.

[4] M. Bouguer, *Traitè du navire, de sa construction et de ses mouvements*, 1747, an English abridgement of which is included in Mungo Murray's *Supplement to the treatise on ship-building*, 1754, along with a summary of M. Du Hamel de Monceau's *Elemens de l'architecture navale*, 1752.

[5] This valuable manuscript has not been published in its entirety, although most of the illustrations can be found in published works. The original has been preserved in the Pepys Library, Magdalene College, Cambridge, and a complete photocopy and transcription can be examined at the National Maritime Museum, Greenwich.

[6] A faithful edition was published in 1922 from the original manuscript by The Navy Records Society in *The Life and Works of Sir Henry Mainwaring, Volume II.*

[7] Deane's manuscript was not published in its entirety until 1981: *Deane's Doctrine of Naval Architecture, 1670* (London, 1981: Conway Maritime Press), edited and introduced by Brian Lavery. The original manuscript has been preserved as manuscript no. 2910 in the Pepys Library, Magdalene College, Cambridge.

[8] A Facsimile was published by Jean Boudriot Publications, Rotherfield, 1989).

[9] A Facsimile was published by Scholar Maritime Press, London, 1979).

[10] Facsimiles of the pertinent drawings and articles were reproduced in 1983 by Arcturus Press, Kent.

[11] Unless otherwise stated, citations for Chapman's works are as follows: For the *Tractat*, information was taken from the 1820 English translation by the Rev. James Inman, while the plates comprising the *Mercatoria* were studied in the 1971 Praeger Publication facsimile edition; this edition is more readily available than the others, and the author has spent many hours lifting measurements from the plates in his personal copy. However, when there was any question of accuracy, the original Swedish editions of both publications were consulted and are referenced in the text, as appropriate. The copies of Chapman's *Mercatoria* and *Tractat* used in this study are in the research library of The Mariners' Museum, Newport News, Virginia.

[12] In the original Swedish edition of the *Tractat*, and in the Inman translation (1820), table No. 1 is placed at the end of the volume, following sixteen folded plates. As a matter of curiosity, Inman (1820:227) heads his section of notes, "Notes on the Architectura Navalis Mercatoria of F. D. De Chapman, &c. &c. &c." —not the *Tractat*, to which the notes actually refer.

[13] In the original Swedish (1775) and Inman translation (1820) editions of the *Tractat*, Figure 32 is found at the end of the volume as Plate 9. The figure is approximately 11 inches long, large enough to be used for the intended purpose of quickly determining a vessel's parameters.

[14] Although the Praeger (1971) publication includes facsimiles of Chapman's plates, his *Tractat* is considerably condensed, making it necessary to refer to the Swedish or English editions.

[15] Again, the original manuscript was consulted for possible transcription errors and, again, there were none; however, the English translation (Inman 1820:85) included a note (note 44) included from the French translation (by Vial De Clarbois) from which Inman extracted most of the English translation. Clarbois's note points out the error and provides the correct value; however, no mention is made of the fact that the error is carried throughout much of the rest of the example.

[16] Chapman's method, according to Fincham (1851:xlv), was not significantly less accurate than the newer method of "Mr. Stirling" and, in fact, "it is doubtful whether the method used now for calculating the cubic contents of the body gives its exact measure."

[17] During the American War, the Navy Board specified 200 tons as the minimum size, although wartime pressures sometimes forced the leasing of smaller vessels.

[18] These records are principally to be found in ADM 106, the records of the Navy Board.

[19] Unless otherwise stated, tonnages expressed in this study represent tons burden computed according to the Builder's Old Method, the standard formula of the day. (See Appendix A for a discussion of tonnage calculations).

[20] These records, found only at the Public Records Office, Kew, are very poorly indexed, thus requiring painstaking research.

[21] There seem to have been no provisions for "hazardous duty pay" for crews of these ships, possibly since eighteenth-century seamen always faced the hazards of the sea, whether from natural causes or from the guns of hostile forces or pirates.

[22] That *Supply* had a remarkably long career, being refitted in 1786 for Botany Bay and finally sold in 1792, after 77 years service (NMM, Navy Progress Book, Vol. 5: Nos. 525 and 527).

[23] The original Carlisle and Whitehaven port registers were examined at the Carlisle County Records Office, Carlisle, Cumbria; the original Newcastle registers were examined at the Newcastle Archives; Liverpool was not included in this study, since the entire register has been published (Craig and Jarvis 1967).

[24] Data were tabulated using a portable computer and Reflex database software, then later exported to Microsoft Excel spreadsheets for analysis and graphing.

[25] The terms "brig" and "brigantine" often referred to the same type of two-masted vessel during this period, and there were numerous variations. Some were square-rigged on both masts, while others only carried fore-and-aft sails on the main; snows were still another variation (See Chapter 1). Craig and Jarvis (1967) caution against reliance on the term "brigantine" in the in the Liverpool Registry.

[26] Lloyd's Register of Shipping is available in numerous libraries, although the earliest volumes are more difficult to locate; this study utilized the complete collection in the Research Library of The Mariners' Museum, Newport News, Virginia.

[27] For 1800, The Lloyd's Underwriters' Edition, not theShipowners' Edition, was used.

[28] MacGregor (1985:81-87) describes both versions in detail.

[29] With permission from the Whitby Literary and Philosophical Society Research Library, these plans were copied and the full-size copies were placed in the extensive collection of ships' plans at the National Maritime Museum Greenwich (NMM WHY).

[30] Mr. Smales's surviving daughter, who still lives in one of the Smales family residences, was contacted in an attempt to locate the original Smales Firm records, but she was under the impression that her father had already donated everything to the Whitby Literary and Philosophical Society.

[31] As noted above, the author of the present study was unable to locate the original masting book or any of the other Smales Firm documents.

[32] The referenced volume is Smales, H.W., c. 1950, "A Register of Whitby Steamships, 1865-1950," ms. in the collection of the Research Library of the Whitby Literary and Philosophical Society, Whitby.

[33] This once again refers to the Old Builder's Method, described elsewhere and in Appendix A.

[34] Tindale was the original spelling of the family name that later became Tindall.

Part II

Archaeological Evidence from Sunken Ships at Yorktown, Virginia

. . . the archaeological evidence [from shipwrecks] remains paramount through to the early nineteenth century.

-- Keith Muckelroy
Maritime Archaeology (1978 :92)

. . . nautical archaeology desperately needs decades of cataloging and categorizing shipwreck remains, for we have so few comparative data with which to work.

-- George F. Bass
Shipwreck Anthropology (1983:97)

The Publications on Marine Architecture, though written by the most able men in the profession, have been hitherto almost entirely adapted to Ships of War, or Merchant-Vessels of the largest dimensions; while the smaller classes, by which the commerce of the different countries of Europe is chiefly carried on, have been greatly neglected.

-- Peter Hedderwick
A Treatise on Marine Architecture (1830)

Part II
Archaeological Evidence from Sunken Ships at Yorktown, Virginia

The documentary data presented in Part I developed a framework for describing and analyzing the relevant shipwrecks described in Part II. Part I investigated the theories and practices employed by eighteenth-century shipwrights and generated a system for analysis that will apply equally well to shipwreck remains. The past two decades have seen a vast increase in the number of shipwrecks that have been scientifically excavated and reported. Particularly relevant are a group of shipwrecks inYorktown, Virginia, several of which are confirmed English merchant vessels hired as military transports by the Royal Navy during the American War of Independence. Those vessels, especially site 44YO88, which was fully excavated during the 1980s under the direction of this author, have provided some of the most detailed information on English merchant vessels yet discovered. Yorktown shipwreck 44YO88 was preserved to a level just above the waterline, thus allowing an accurate set of lines to be taken from the vessel up to that level.

Chapter 4 begins with a brief historical account of the vessels, then describes the initial archaeological investigations. Chapter 5 provides details on the excavation and analysis of the best-preserved site, wreck 44YO88, later identified as the English collier brig *Betsy*. Archaeological and archival data made it possible to develop a complete reconstruction of the vessel, including a sail plan, as presented in Chapter 6, along with other interpretive material.

Chapter 4

Remains of English Merchant Vessels at Yorktown, Virginia

The Yorktown Shipwreck Archaeological Project was conducted between 1978 and 1989 by the author, who was Senior Underwater Archaeologist for the Virginia Department of Historic Resources.[1] The Yorktown Project investigated British vessels sunk during the Battle of Yorktown (Virginia) in 1781. These were primarily merchant vessels leased as transports and victuallers, provided a unique opportunity to study the physical remains of British merchant vessels from the eighteenth century. It was the archaeological investigation of the Yorktown shipwrecks that provided the initial incentive for the present study.

The naval aspects of the Battle of Yorktown (Sands 1983) and the role of the British transports in the American War (Syrett 1970) have been thoroughly described and analyzed; however, a brief summary of the events leading to and culminating in the Battle of Yorktown is presented below to provide a historical framework for the archaeological results that follow.

The Loss of British Shipping at Yorktown

The Southern Campaign

The American War of Independence taxed British resources, especially as it had to be fought simultaneously with hostilities on the Continent. British campaigns in the American southern colonies had proved more frustrating than successful. By 1778 a new strategy, advocated by Lord George Germain, was adopted in the hope of bringing the rebellious colonies to heel (Sands 1983:2). The objective of the southern strategy was to occupy and control the colonies still loyal to the Crown, seize and hold the southern colonies with large Loyalist populations and deny the southern colonies the ability to trade by sea. Although the British met with some success, by the spring of 1781 Clinton had become frustrated by unsuccessful campaigns in the Carolinas. This frustration, coupled with his fears of an Allied assault on his positions in New York, led Clinton to order several units of the Southern British Army, Major General Charles, Earl Cornwallis commanding, to retire north to strengthen his defenses.

On April 17 Cornwallis's army, along with his large fleet of supply and support vessels, joined forces with British troops under General Benedict Arnold at Petersburg, Virginia. The new combined force, under Cornwallis's command, arrived in Portsmouth, Virginia after a series of minor engagements with rebel forces in the area. Once in Portsmouth, Cornwallis began embarking the requested troops aboard naval transport vessels for the voyage to New York.

However, before these troops sailed, Cornwallis received new orders from Clinton. He was instructed to establish a post in the lower Chesapeake with a fortified harbor that could serve as an ice-free winter port for the British fleet, then in New York. Clinton anticipated utilizing this new post as a base for expanded operations in the Chesapeake the following year. After investigating several locations, Cornwallis eventually selected Yorktown (Figure 4.1), reporting to Clinton on July 27:

> I shall, in obedience to the spirit of your Excellency's orders, take measures with as much dispatch as possible, to seize and fortify York and Gloucester, being the only harbour in which we can hope to be able to give effectual protection to line of battle ships (Quoted in Stevens 1898:II:107).

The Establishment of a British Post at Yorktown

Utilizing his large supply fleet, Cornwallis moved his force to Yorktown, taking possession of the town on August 1, 1781. Here, Cornwallis began to prepare fortifications in anticipation reinforcements from New York. Soon, British troops occupied both sides of the river and his supply fleet rode at anchor in front of Yorktown and Gloucester Point (Johnston 1881:69-70).

At this time, Cornwallis's supply fleet was composed of an impressive array of vessels consisting of five relatively small warships, approximately fifty transports and armed merchantmen, at least seven captured prizes and a variety of small sloops, schooners and rowing craft (Sands 1983:59). With this fleet, Cornwallis possessed the capability to move his army out of Yorktown quickly, by sea, should that option become necessary. This advantageous position, however, was soon to change.

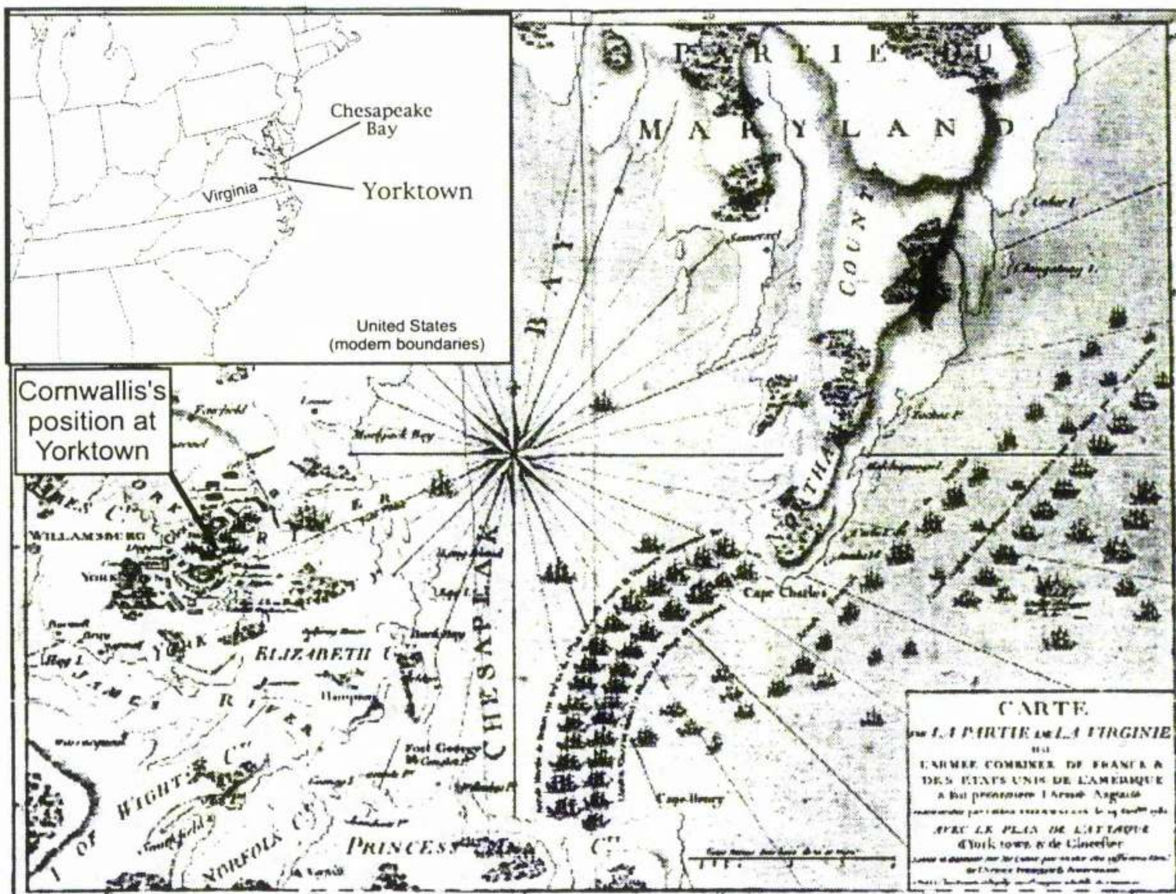


Figure 4.1. A map printed in Paris soon after the Battle of Yorktown, depicting several events: Cornwallis's fortifications at Yorktown, the Battle of the Virginia Capes, and the French blockade of the Chesapeake Bay and the York River. (The Mariners' Museum)

General George Washington, commander of all allied French and American forces, recognizing an opportunity to trap and defeat Cornwallis at Yorktown, sought assistance from Admiral Francois Joseph Paul de Grasse, commander of a large French fleet then in the West Indies, entreating him to lend support in the Chesapeake. Washington was well aware that an Allied victory would depend upon sea power capable of trapping Cornwallis at Yorktown. Only the French possessed such naval strength (Tilley 1987:252-253; Johnston 1881:97-99). On August 28, Washington's efforts were rewarded. The Comte de Grasse arrived at the mouth of the Chesapeake Bay with his fleet of 26 warships, anchoring in Lynnhaven Bay, just inside the entrance to the Chesapeake. With him, de Grasse brought a significant number of troops and supplies.

Cornwallis soon learned of the presence of the enemy fleet. However, his small warships were no match for the large French ships-of-the-line, so Cornwallis could only await the arrival of reinforcements from New York. In the meantime, he continued his efforts to establish a secure post at Yorktown. Here, his fleet of supply vessels played a major role. On August 31 a Hessian soldier, J. C. Doehla, wrote in his journal:

> I was on unloading duty. All the munitions and provisions were unloaded from the ships riding in the harbour, the lower tiers of guns from the warships and frigates brought into the earthworks and all the ships completely emptied (Doehla 1781: 251).

As Cornwallis's army reinforced their post at Yorktown, an important confrontation was developing just off the Virginia coast.

The Battle of the Virginia Capes

When the British fleet, commanded by Rear Admiral Thomas Graves, arrived off the Virginia Capes on September 5 to join Cornwallis, it confronted de Grasse's fleet at anchor near Lynnhaven Bay, guarding Hampton Roads and keeping a watchful eye on Cornwallis's escape route at the mouth of the York River.

Adhering to a conservative doctrine of naval warfare, Graves forfeited his advantageous position and allowed the French fleet to sail out and form a line of battle. The ensuing engagement was tactically indecisive, with neither side losing any vessels during the battle (although the British scuttle one badly-damaged warship afterwards). However, because of damage suffered by the British fleet and reports of the impending arrival of additional French warships, Graves elected to return to New York to repair and refurbish his ships, and to consider the new French naval threat more carefully. This decision left the Chesapeake Bay under French control, a situation which was to prove critical to the events at Yorktown. Thus the Battle of the Virginia Capes, while tactically inconclusive, became a strategic victory for the Allies (Sands 1983:56).

The Siege of Yorktown

Following the withdrawal of the British fleet, the French dispatched a squadron to the mouth of the York River while the main body of the fleet remained at Lynnhaven. Upon learning of this shift in seapower, Cornwallis recognized the need to strengthen and hold his post until the British fleet returned. With the French in undisputed control of the Chesapeake Bay, Cornwallis's army was effectively bottled up at Yorktown. Washington quickly moved to spring the trap, assembling his combined American and French land forces at Yorktown.

Placing his trust in the Royal Navy to quickly come to his relief, Cornwallis elected to hold the post at Yorktown, ordering his fortifications to be strengthened. On September 16, Cornwallis notified Clinton that he felt that he could hold Yorktown until reinforcements arrived (Stephens 1898:II:157). Meanwhile, Washington met with de Grasse aboard the latter's flagship *Ville de Paris* on September 18, eliciting a promise from the Admiral to maintain his control over the Chesapeake until the end of October, by which time both men hoped an Allied victory would be assured. Barely a week later, when de Grasse sent word that the threat of additional British warships from the West Indies made it necessary for his fleet to depart to cruise offshore, Washington replied with a confident and determined summary of the critical need for continuation of the French blockade:

> Give me leave in the first place to repeat to Yr Excellency that the enterprise against York under the protection of your Ships, is as certain as any military operation can be rendered by a decisive superiority of strength and means; that it is in fact reducible to calculation, and that the surrender of the british [*sic*] Garrison will be so important in itself and in its conse-

> quences, that it must necessarily go a great way towards terminating the war, and securing the invaluable objects of it to the Allies (Quoted in Sands 1983:59).

Yielding to the logic of Washington's argument, de Grasse agreed to remain for a short time.

By mid-September, realizing that an attack on his army was imminent, and with no word on British reinforcements, Cornwallis shortened his lines to strengthen his position and evacuated all noncombatants. Now that his fleet no longer offered a viable means for escape, Cornwallis also ordered a group of his vessels to be scuttled along the Yorktown beach to hinder an anticipated French amphibious landing (Figure 4.2). Hessian Captain Ewald of the Field Jäger Corps recorded that "on the 16th [of September] we began to sink ten transport ships between York and Gloucester to obstruct the entrance" (Quoted in Sands 1983:63). A Williamsburg resident, St. George Tucker, confirmed in his journal on October 2 that "the British had sunk several square rigged Vessels near the Shore and at the distance of one hundred and fifty, or two hundred yards from it ..." (Tucker 1781:382). Two days later, a man leaving Yorktown by boat was interrogated by American officers and the following report was made to Washington:

> Ten or twelve large merchant ships have been sunk before York, and piles have been driven in front of these vessels, to prevent our ships from approaching the Town sufficiently to debark Troops ... (From Washington Papers, quoted in Sands 1983:63).

Apparently, some of the ships were sunk in very shallow water, leaving their upper decks above water, and allowing pickets to be stationed aboard to guard the river approach (Doehla 1781:251).

On September 22, the British attempted to break through the blockade using fireships, nearly all of which were transports fitted out to be ignited in close proximity to enemy vessels with the intent of setting them afire. If effective, this tactic might have allowed the trapped British fleet to escape into the Bay. Late that night, Captain Palmer, of HMS *Vulcan*, a purpose-built fireship, led his group of four fireships down to the French ships anchored near the mouth of the York. One of the fireships was ignited too early, however, thus

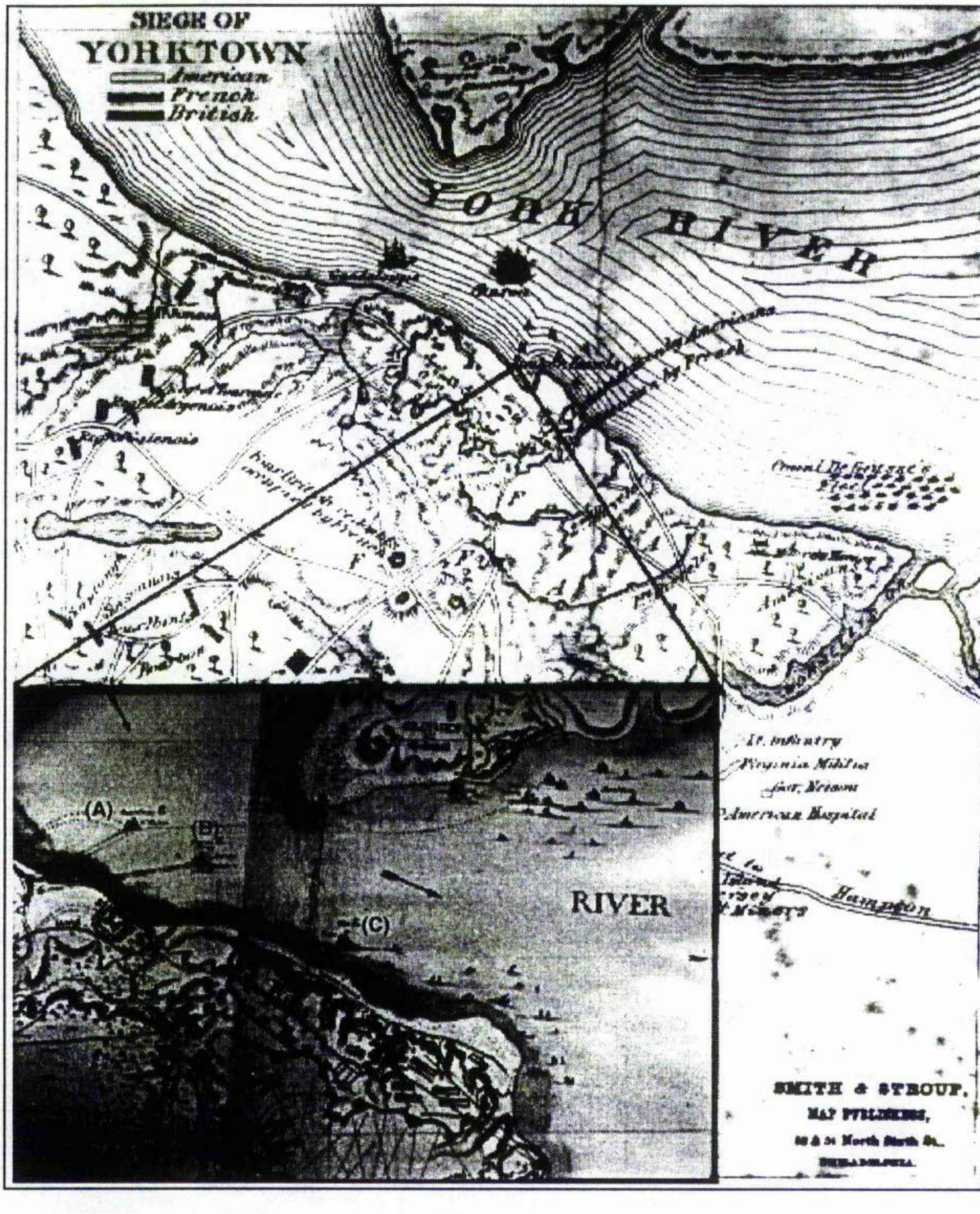


Figure 4.2. Two contemporary maps of Yorktown, showing the disposition of shipping. The inset shows the position of the Guadaloupe *(A),* Charon *(B) and* "Fox" *(C), which is actually the Fowey. Numerous sunken vessels are depicted along the Yorktown shoreline and also on the north shore at Gloucester Point. (The Mariners' Museum)*

alerting the French, who acted quickly to save their ships. Although two French warships were grounded while attempting to avoid the fireships, they were refloated on the next high tide, apparently with no serious damage (Laughton 1896:117, cited in Sands 1983:60). The French warships returned immediately to their blockading stations within sight of the British troops at Yorktown (Tucker 1781:382). Thus one of the last remaining British options was poorly executed, and the British fireships were lost to no avail.

While these minor skirmishes were taking place on the river, Allied troops were preparing for the much-anticipated siege. By September 28 French and American forces had massed at Yorktown. On September 30 the first approach trenches were dug and on October 6 the first parallel trench was opened. The ring around Yorktown was closed.

Apparently, Cornwallis realized that the situation at Yorktown was becoming less tenable. This study located the log book of the *Emerald*, one of the British transports listed as sunk at Yorktown.[2] The log reported that on October 9 Captain Todrock of the transport *Andrew* ordered the *Emerald* to be sunk. The crew obediently scuttled their ship in 22 feet of water. Other merchant ships were added to the "sinking line," thus ensuring that the fleet would not fall into enemy hands (Log of the *Emerald*, 9 October 1781).

The bombardment opened later that same day, October 9, with much of the early Allied fire being directed at the British ships anchored near shore. That evening HMS *Charon* was set afire by red-hot shot from a French battery (Figure 4.3). *Charon* drifted helplessly with the current, eventually running aground near Gloucester Point after colliding with and igniting the *Shipwright* and another transport (Log of the *Emerald*, 9 October 1781). The power of this event was captured by an American surgeon, Dr. Thacher, who watched from shore:

> A red-hot shell from the French battery set fire to the Charon, a British 44-gun ship, and two or three smaller vessels at anchor in the river, which were consumed in the night. From the bank of the river, I had a fine view of this splendid conflagration. The ships were enwrapped in a torrent of fire, which spreading with vivid brightness among the combustible rigging, and running with amazing rapidity to the tops of the several masts, while all around was thunder and lightning from our numerous cannons and mortars, and in the darkness of night, presented one of the most sublime and magnificent spectacles which can be imagined (Thacher 1781:283).

The following day the British prudently withdrew their remaining vessels to Gloucester. Even there, however, they were not safe, as the Hessian Doehla explained in his diary entry of October 11:

> These ships were miserably ruined and shot to pieces .... I saw with astonishment today on my watch how the enemy cannon balls of 24 and more pounds flew over our whole line and the city into the river, where they often struck through 1 and 2 ships, and indeed even struck 10-12 times in the water; yes, some even went clear across the river to Gloucester, where they even injured some soldiers on the beach (Doehla 1781:251).

By mid-October the siege lines had tightened and numerous outlying British positions had been captured. Heavy siege guns kept up a constant rain of shot and shell as casualties slowly mounted. Realizing that reinforcements from New York were not likely to arrive in time, the British began destroying equipment that might fall into enemy hands. On October 13, the Master's log of HMS *Fowey* recorded matter-of-factly: "P.M. bored holes under the Starboard fore chains to sink the Ship pr. order from Captain Symonds" (Quoted in Sands 1983:82). Two days later, HMS *Guadeloupe* and most of the remaining supply ships were also scuttled.

On the night of October 16, with no sign of relief, Cornwallis ordered his troops to attempt an escape in small boats across the river to Gloucester Point, where French forces were weaker. This attempt was thwarted by a sudden severe storm, which drove several of the small boats downstream and others ashore. Following this latest disaster, Cornwallis

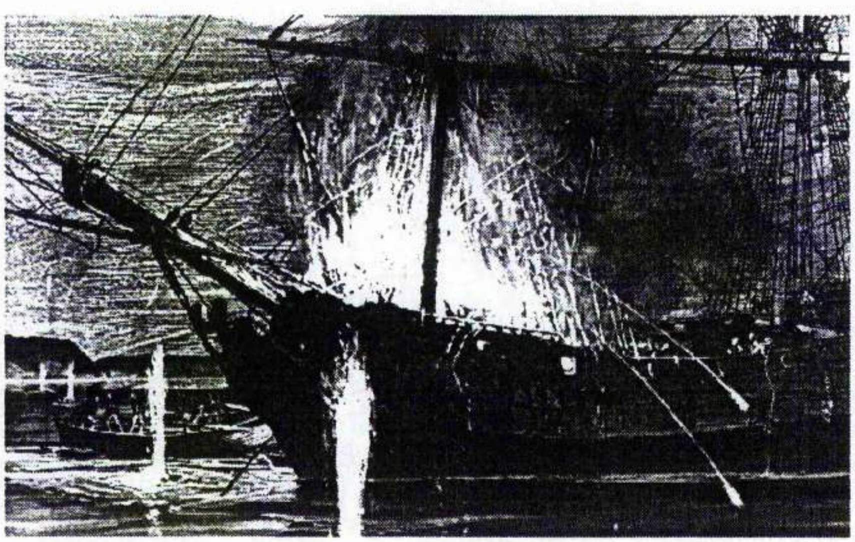


Figure 4.3. Artist's impression of the burning of HMS Charon *at Yorktown, October 9, 1781. (Louis S. Blanzman © 1988 National Geographic Society)*

recognized that further resistance was futile; he asked for terms of surrender on October 17. On October 19, 1781, the Southern British Army laid down arms, having miraculously lost only 156 dead. Ironically, and unknown to Cornwallis, Clinton finally dispatched a relief fleet from New York that very day (Sands 1983: 88).

Thus ended the battle which proved to be the last major engagement of the American Revolution. Although it would be two years before a treaty was signed, French sea power had turned the tide of the war during the fall of 1781.

The Disposition of British Shipping at Yorktown

At the time of the British surrender, nearly all of Cornwallis's ships lay on the bottom of the York River. In his journal, St. George Tucker described the condition of the British fleet at that time:

> Thursday 18th ... At a small distance from the Shore were seen ships sunk down to the Waters Edge--further out in the Channel the Masts, Yards & even the top gallant Masts of some might be seen, without any vestige of the hulls. On the opposite of the river the remainder of the shipping drawn off as to a place of security. Even here the Guadeloupe sunk to the Waters Edge shew'd how vain the hope of such a place . . .. A painter need not to have wish'd for a more compleat subject to imploy his pencil without any experience of Genius (Tucker 1781:391).

The actual number of vessels and their respective fates is difficult to ascertain from documentary sources. In his briefing to the Continental Congress, Washington's aide-de-camp, Colonel Tench Tilghman, reported,

> ... the vessels amount to about 100 sail, fifty of which may be called transports: that among the shipping, are the Guadaloupe, a frigate of 28 guns, and Bonetta Sloop of War, with two or three other armed vessels: that most of them are sunk, but can easily be raised (Quoted in Sands 1983:93).

A similar report was made by Captain Symonds to Admiral Graves, stating that of the five naval vessels, only the *Bonetta* was afloat; and of the thirty-two transports and victuallers listed, all but two were sunk (Sands 1983:86).

The Articles of Capitulation signed at Yorktown awarded possession of all shipping, whether sunken or afloat, to the French. The French took possession of all shipping immediately after the battle, soon learning that most of the vessels lay on the bottom of the river. Salvage of the Yorktown shipwrecks began almost immediately.

De Grasse assigned Captain Guillaume Jacques-Constant de Liberge de Granchain, Admiral de Barras's chief administrative officer, the task of dealing with the newly-acquired shipping. Because of the potential value of such a large number of vessels, the French decided to initiate salvage operations. When the French naval fleet departed Yorktown, soon after the British capitulation, the duty of salvaging the sunken fleet was assigned to Captain La Villebrune, of the *Romulus*. He had four naval vessels at his disposal, but little in the way of salvage equipment.

La Villebrune's report of January 30, 1782 suggests strongly that many of the British vessels survived the battle:

> I have sold [many of] the boats and sloops which are of use in the navigation of the rivers . . .. The large vessels, on the other hand, have had little demand ... (La Villebrune to unknown, quoted in Sands 1983:111).

That the large vessels to which La Villebrune refers were unlikely to have been ones that he, himself, previously salvaged is implied in his same report:

> I have raised very few of the vessels; the apparatus necessary for these operations ... has not been given to me ...; my first attentions will be given to the Guadeloupe, as soon as good weather permits (La Villebrune to unknown, quoted in Sands 1983:111).

In another report of the same date, La Villebrune complains, "The prizes taken in York having been plundered before my arrival, they do not offer the means to repair our vessels ...." (La Villebrune to unknown, quoted in Sands 1983:112). It is not clear if he refers to removal of equipment from only the floating vessels or whether there may already have been some salvage of the sunken ships. The moderate temperature of the water in October and the shallow depths would have made such salvage quite attractive to local residents as well as military personnel.

Although no satisfactory account of all the shipping has been located, at least twenty-six vessels from the decimated British fleet remain unaccounted for in documentary sources (Sands 1983:108). These vessels are presumed to have been sunk during the Battle of Yorktown. Although some were salvaged, most were probably left to disintegrate on the bottom of the York River.

Discovery and Investigation of the Yorktown Shipwrecks

With the commencement of the Yorktown Shipwreck Archaeological Project in 1978, a comprehensive survey strategy was developed and utilized in locating the remains of British ships thought to lie beneath shallow waters near Yorktown. A complex survey plan was necessitated by the large area to be surveyed, the likelihood that the wrecks were partially or completely embedded in the river bottom, and the extremely poor conditions for diving (particularly the strong currents and near-zero visibility). The resulting shipwreck survey—one of the most successful ever conducted—located and examined nine shipwrecks confirmed to be associated with the 1781 Battle of Yorktown.

Survey Methodology

An initial volunteer survey at Yorktown in 1975 by the author and others revealed the presence of a large, partially-exposed wooden vessel that came to be known as the "Cornwallis Cave Wreck." This discovery, coupled with historical research by John O. Sands, strongly suggesting the survival of other shipwrecks, inspired further surveys (Sands 1983; Watts, Broadwater and Sands 1975). During the following five years several remote-sensing surveys were conducted, utilizing a combination of state-of-the-art electronic instruments and ground-truthing by divers (Andahazy 1976; Sands 1983).

Once all electronic "targets" had been mapped and evaluated, the archaeological team donned diving gear and began locating, examining all promising sites. Various techniques for combatting the adverse diving conditions were tested; however, the effectiveness of the surveys was probably due more to the improving skills of the dive team than to the success of the attempted methodology. Individual underwater sites were generally mapped using a simple system of trilateration from a reference baseline. Although the method itself was simple, the actual mapping operation in the adverse river conditions was extremely difficult and required considerable skill and experience. A computer program was developed to convert sets of distance measurements to x and y coordinates, a method that simplified plotting, improved accuracy and lessened the chance of plotting errors (Broadwater 1982).

General Survey Results

Ten shipwrecks were located and examined, nine of which have been confirmed to be British vessels from the Battle of Yorktown (Broadwater 1980, 1981). Of particular relevance to the present study, seven of the nine Yorktown wrecks proved to be merchant vessels believed to have been under contract as naval transports. The dynamics of the York River system determined, to a large extent, the relative survival of the shipwrecks. Those shipwrecks nearest the narrow constriction between Yorktown and Gloucester Point are rapidly eroding, while those further downriver, particularly 44YO88, 44YO89 and 44YO94, are protected from river currents by a layer of silt and are very well preserved. The extent of deterioration differed markedly from site to site. All of the wrecks were embedded to some extent in river bottom sediments, making limited excavation necessary for even the most basic data recording. Poor diving conditions, a small staff and minimal equipment all limited the amount of data recovery.

Basic survey results are presented in Table 4.1 and Figure 4.4. The descriptions below are based on both archaeological evidence and historical research. Referring to Figure 4.4, the wrecks are discussed in order of their position, beginning with the two wrecks near Gloucester Point, then moving west-to-east along the Yorktown shoreline, and finally to a wreck deep in the York River channel.

Wrecks near Gloucester Point

44GL106: This site was discovered near Gloucester Point in 1978, during a search for HMS *Charon*. The hull was completely buried except for the eroded ends of a few frames, from which a rough outline of the wreck was mapped. No excavation was con-

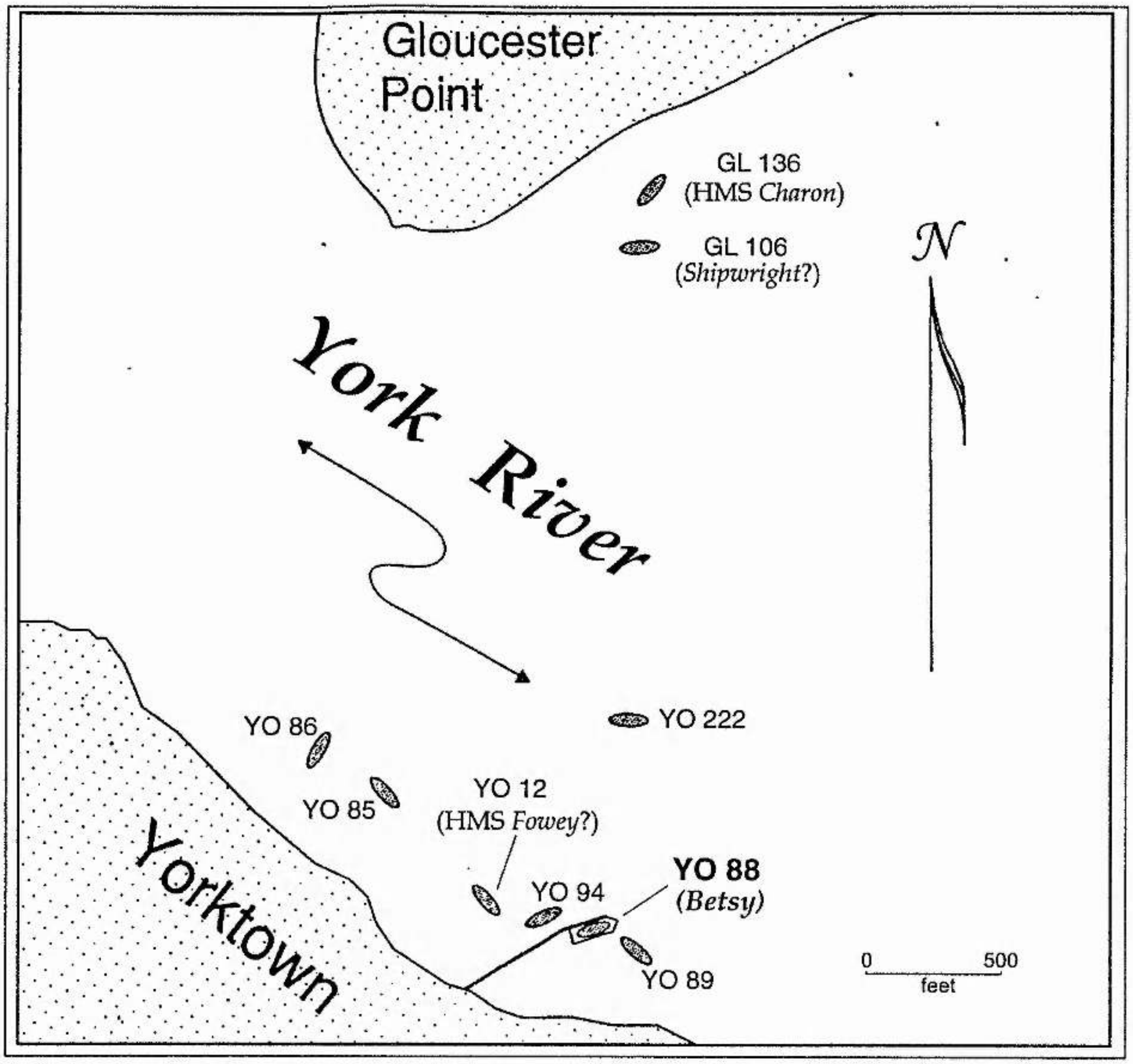


Figure 4.4. Map showing the nine British shipwrecks near Yorktown. (Map by John D. Broadwater)

Table 4.1. Summary Information on the Yorktown Shipwrecks[3]

			Estimated Data				
Site No.	**Identity**	**Vessel Type**	**Tonnage**	**Length**	**Breadth**	**Preservation**	**Water Depth**
YO 86		merchant	330	96'	28'	5-10 %	20-45'
YO 85		merchant	200	79'	20'	5-10 %	18-25'
YO 12	HMS *Fowey*?	warship?	512	116'	31.5'	20 %	15'
YO 94		merchant	431	108'	30'	40 %	20'
YO 88	*Betsy*	merchant	176	72'	25'	50 %	16-22'
YO 89		merchant	354	92'	30'	40 %	20'
YO 222		merchant	---	--	--	--	80'
GL 106	*Shipwright*?	merchant	301	89'	28'	20 %	20-25'
GL 136	HMS *Charon*	warship	891	112'	30'	10 %	10-15'

ducted. The recovery of an iron cannon (Figure 4.5) once again fueled speculation that the *Charon* had been located. However, after the cannon was cleaned and measured, it proved to be a six-pounder, too small for any of *Charon*'s armament (Broadwater 1980, 1981). The log of the Yorktown transport *Emerald*, located in England by the author, contains an account of the transport *Shipwright* being accidently rammed and set afire on October 9 by *Charon*, which was adrift and burning (Log of the *Emerald*, October 9, 1781). The *Shipwright* was listed among the vessels sunk during the battle. Extrapolation of the hull remains yielded an estimated size of 301 tons, which is exactly equal to the tonnage recorded for *Shipwright*.[4] The six-pounder iron cannon found on the site also matches her listed armament. Therefore, it seems reasonable to conclude that site 44GL106 is the transport *Shipwright*, a former merchant ship.

44GL136: This wreck was also discovered in 1978, shortly after the location of 44GL106. Almost immediately the survey team encountered fragments of copper hull sheathing. The sheathing was strong evidence that this site was HMS *Charon,* a 44-gun, fifth-rate warship, since at the time of the American War, copper sheathing was a relatively new technique, generally reserved for warships. Additionally, it was known that *Charon* and *Guadaloupe* were the only warships lost on the Gloucester shore, and *Guadaloupe* was later salvaged (Broadwater 1980, 1981; Sands 1988).

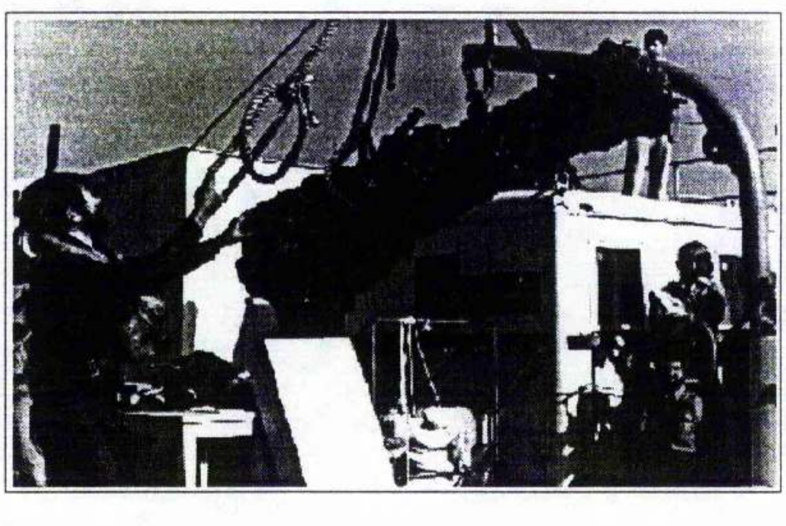


Figure 4.5. The recovery of an iron cannon from Yorktown shipwreck 44GL106 in October, 1978. (Copyright © 1978 Daily Press, Newport News, VA)

Test excavations conducted in 1980 by a field school team from the Nautical Archaeology Program, Texas A&M University, confirmed the identity of this site as HMS *Charon*, (Figure 4.6). Only approximately five percent of the hull remained. As it burned, the ship settled onto an oyster bed that prevented the hull from sinking into the protective mud on the river bottom. Also, the site was the subject of salvage operations in 1934 and 1935. Even with minimal remains, however, several key features were located and mapped. A positive identification was made possible by the fact that copies of Admiralty draughts of the *Charon*, including as-built drawings, were obtained from the National Maritime Museum, Greenwich, England. Measurements of the extant lower hull, including portions of the keelson, stancheon steps and pump box, matched those taken from *Charon*'s draughts. Supporting evidence, in addition to the copper sheathing, included a variety of musket parts and flints, objects marked with the "broad arrow" symbol of the British Board of Ordnance, other military items and numerous burned and melted objects. Since *Charon* was a warship, it will not be discussed further; interested readers are referred to Steffy, *et al*. 1981 and Sands 1988.

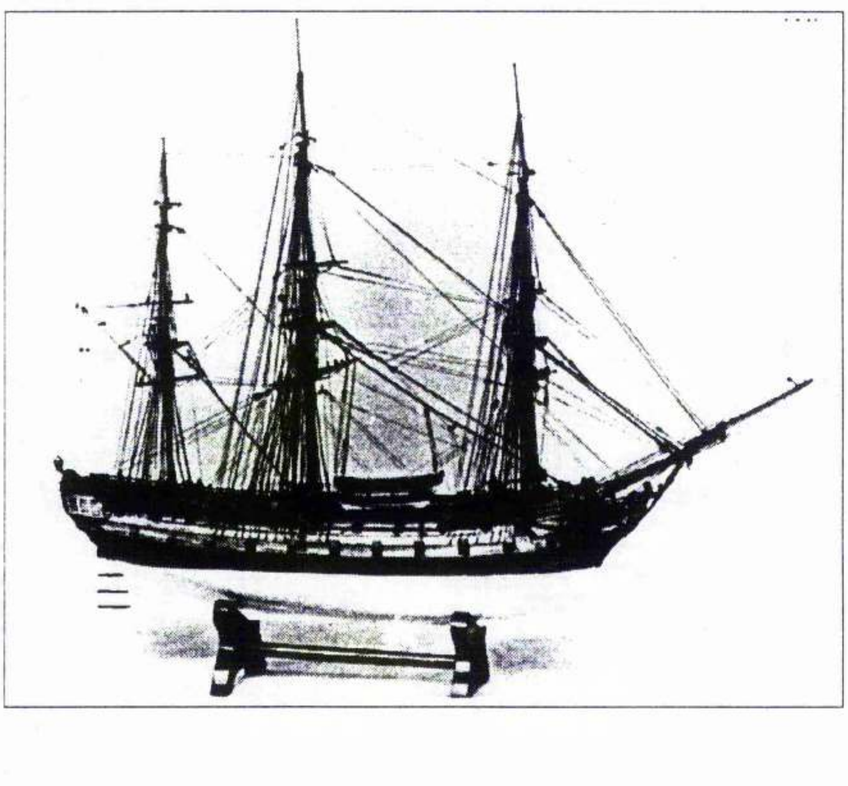


Figure 4.6. A 20th-century model of HMS Charon. (Photo courtesy of The Mariners' Museum)

Wrecks near Yorktown

44YO86: This badly deteriorated wreck lies approximately 500 feet from shore on a relatively steep slope at the edge of the river channel where erosion is actively removing material from the site. The steep slope and strong current make this a difficult site to dive, thus only limited data were recovered (Hazzard 1982). The remains consist of a stone ballast mound that protrudes approximately three feet above the bottom, some articulated hull bottom timbers and partially-exposed disarticulated timbers and artifacts (Figure 4.7). The keel measured 12-14 inches wide by 14 inches deep, while a timber believed to be the keelson was only 9 x 8$^1/_2$ inches.[5] Near the stern a section of articulated hull revealed a large baulk of deadwood measuring 14 inches sided, with attached half-frames of 11-15 inches sided spaced approximately 12 inches apart. YO86 was formerly believed to be the remains of HMS *Fowey*. However, the present study has concluded that it is more likely a transport of approximately 330-360 tons, possibly the *Diana*, 327 tons, or the *Sally*, 330 tons.

44YO85: This site is the remains of a badly-deteriorated vessel lying approximately 500 feet from shore in 18-25 feet of water (*Ibid.*). As seen in Figure 4.8, the site consists of a large stone ballast mound that protrudes approximately six feet above the river bottom, and articulated hull bottom timbers buried in the silt. In order to collect maximum information with minimum site disturbance, five trenches were excavated at key intervals along the line of and perpendicular to the keel, as shown on the site plan.

In the bow a timber believed to be the keel was uncovered at what appears to be the stem scarph. At that point the keel measures 11 inches, sided. The keelson was 14 inches sided by 12-14 inches, moulded. Frames had varied widths of 7-12 inches, with 1$^1/_2$ inch spacing between.

Figure 4.9 is a section through the mainmast step, Trench 5. The step, reinforcing timbers, and pump box are illustrated in Figure 4.10. In the midships trench, frames measured 11, 11, 10$^1/_2$, and 14 inches, with little spacing between. Outer planking measured 2 inches in thickness and approximately 9-10 inches wide. Ceiling was $^3/_4$ by 8-9

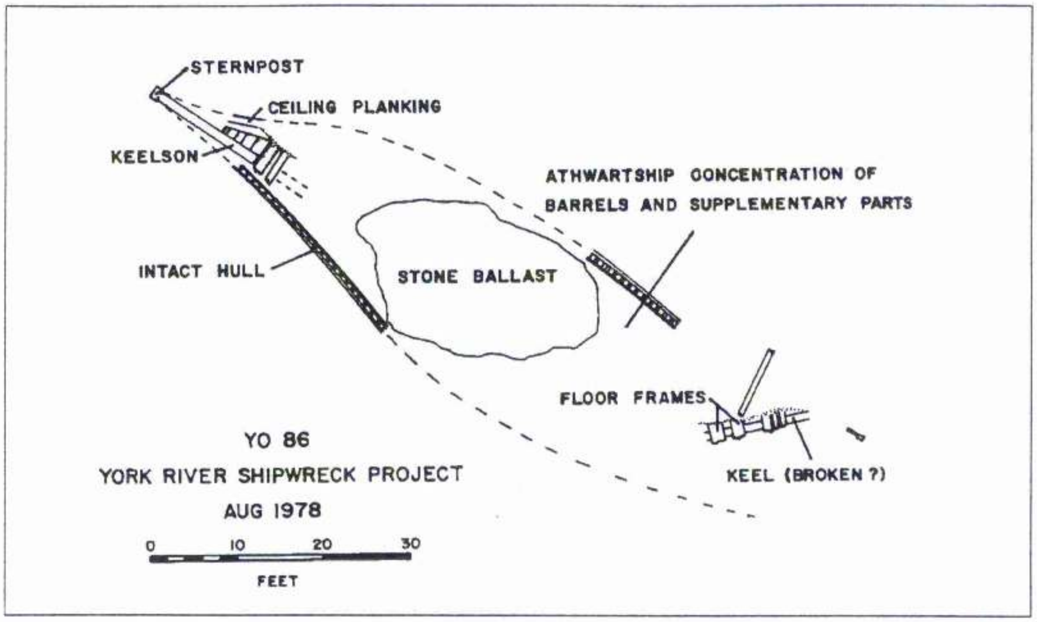


Figure 4.7. Site plan of Yorktown shipwreck 44YO86, showing the poor state of preservation. (Drawing by David K. Hazzard, Virginia Department of Historic Resources)

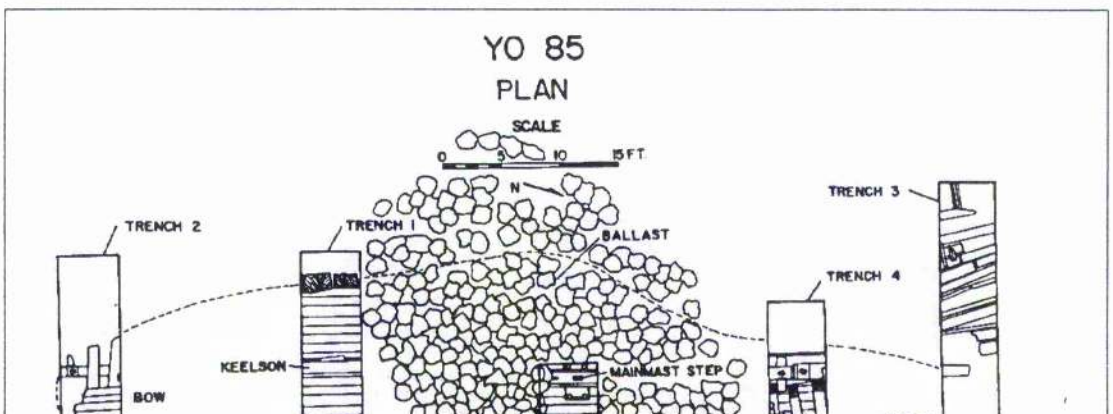


Figure 4.8. Site plan of Yorktown shipwreck 44YO85, showing the large ballast mound and the locations of the five test trenches. (Drawing by David K. Hazzard, Virginia Department of Historic Resources)

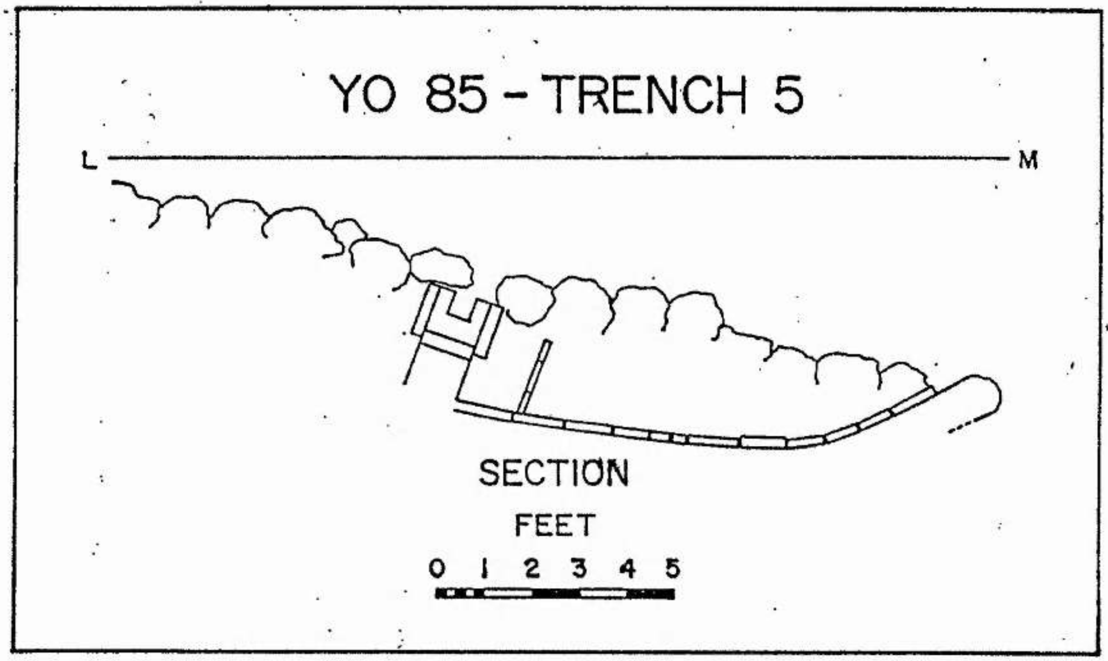


Figure 4.9. Section through mainmast step of Yorktown shipwreck 44YO85, showing the large ballast mound and the locations of the five test trenches. (Drawing by David K. Hazzard, Virginia Department of Historic Resources)

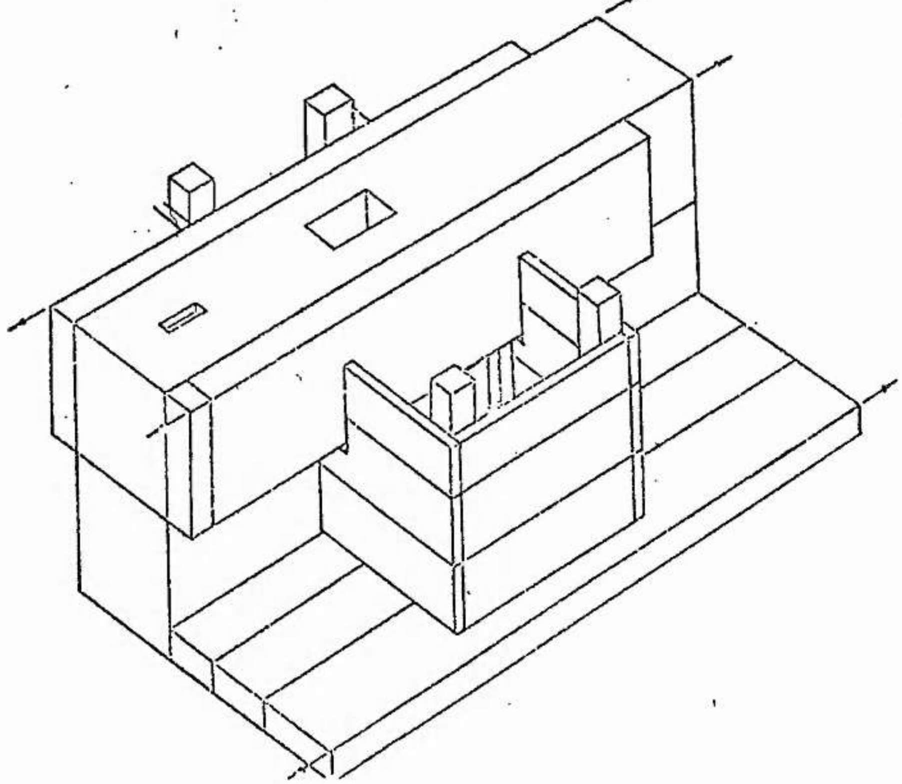


Figure 4.10. Isometric view of mainmast step of Yorktown shipwreck 44YO85, showing the step reinforcements and pump box. (Drawing by David K. Hazzard, Virginia Department of Historic Resources)

inches. Based on the minimal remains, a partial reconstruction of the hull sections was attempted. This tentative reconstruction suggests a vessel with a fairly full midsection, relatively hard chine and somewhat sharp ends. In other words, the vessel does not appear to have the boxlike shape characteristic of bulk-cargo carriers such as YO88.

Based upon testing and analysis, YO85 is believed to have been a merchant ship of 150-200 tons, possibly built in the Chesapeake colonies. This conclusion is based primarily on the determination that many of the types of wood utilized in her construction are native to North America and not normally utilized by British shipwrights. One possible identity is the *Harlequin*, built at Gloucester Point in 1778, although the tonnage listed in historical records (40 tons) is inconsistent with the remains at the site.

44YO12: This site has long been referred to as the "Cornwallis Cave Wreck," because of its proximity to a shallow cave on the Yorktown shoreline which is reported to have served as a bombproof headquarters for Lord Cornwallis during the siege. YO12 lies approximately 300 feet from shore in only 15 feet of water. Until disturbed by sport divers in the mid-1970s, the wreck was completely buried in river silt. The site was first surveyed in 1975 by a volunteer team that included the author (Broadwater, Watts and Sands 1975).

In 1976, YO12 was examined by a team of researchers from the American Institute of Nautical Archaeology,[6] and was estimated to be a large transport of approximately 550 tons (Bass, et al. 1976; Johnston, Sands and Steffy 1978; Figure 4.11). However, subsequent research during the present study found that there were no transports of such large size listed among the Yorktown fleet. Therefore, the present study reexamined the original field data, resulting in slight revisions to the estimated hull dimensions. The overall length was reduced from 118 to 116 feet and the beam from 32 feet to 31.5 feet. These new dimensions yielded an estimated tonnage of 512. This tonnage is still much larger than the two largest Yorktown transports, the *Elizabeth* and the *Providence*, both reported sunk during the battle. The only vessel in Cornwallis's fleet which approximates the size of YO12 is HMS *Fowey*, a sixth-rate warship listed at 513 tons, confirmed to have been scuttled at Yorktown before the British capitulation.

It had previously been predicted that site YO86 was the *Fowey*, based upon information from excavations conducted during the 1930s, and that YO12 was a large merchantman (Bass, et al. 1976; Johnston, Sands and Steffy 1978; Sands 1983). However, the current examination strongly suggests that YO12 is, in fact, the *Fowey* and that YO86 is a transport of possibly 330-360 tons. Supporting this hypothesis are the hull dimensions and shape, the general site location and the fact that numerous artifacts from the site were marked with the "broad arrow," indicating that the items were Crown property. Discrepancies, however, include the fact that the knightheads and bulkheading shown in the *Fowey*'s deck plans, recorded in 1777, appear to differ from those at site YO12 (Figure 4.12). Only additional excavation and analysis can resolve the question.

44YO94: This wreck is also well-preserved and lies within 30 feet of YO 88. Although the site was completely buried and, therefore, received only a cursory examination, it is clear that this was a large ship of approximately 430 tons. This tonnage is close to that of the two largest Yorktown transports, the *Elizabeth* and the *Providence*, both listed at 400 tons and both reported sunk during the battle.

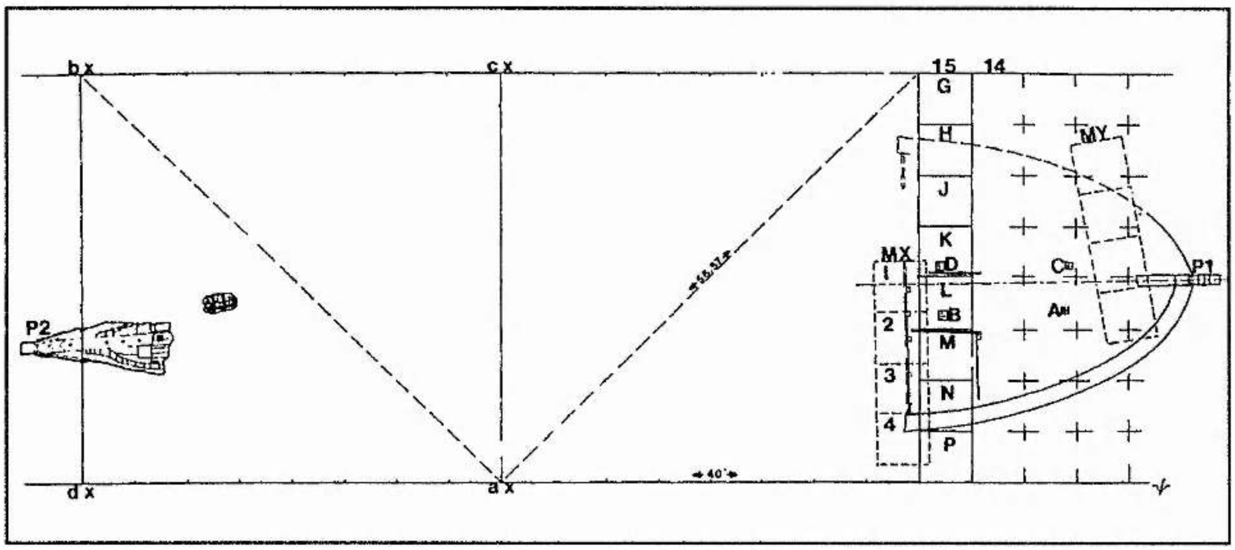


Figure 4.11. Plan view of Yorktown shipwreck 44YO12, showing the excavations forward and aft. (Drawing by J.R. Steffy, Institute of Nautical Archaeology)

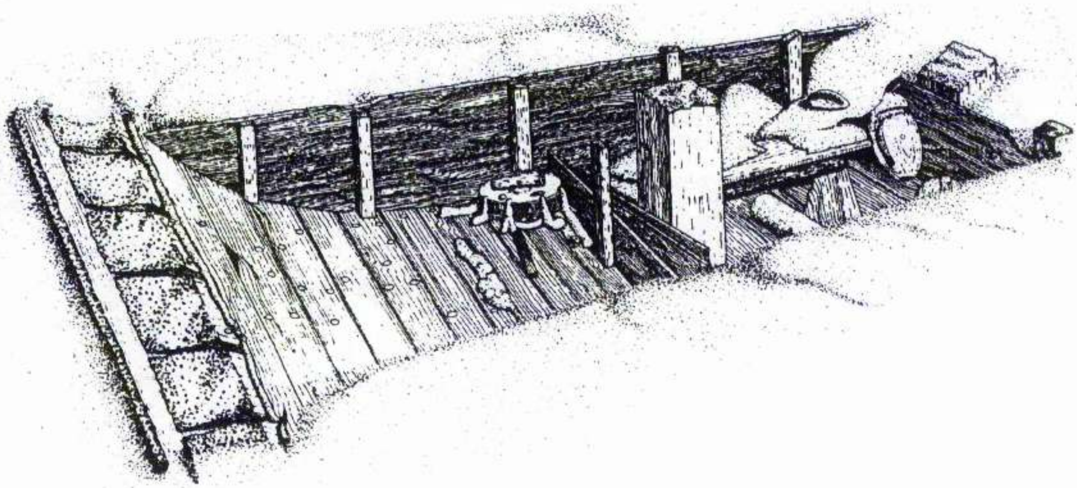


Figure 4.12. Plan view of Yorktown shipwreck 44YO12, showing the excavations forward and aft. (Drawing by Donald H. Keith, Institute of Nautical Archaeology)

44YO88: This shipwreck was completely excavated during the period 1983 to 1988 as the major focus of the Yorktown Shipwreck Archaeological Project. Subsequent analysis revealed that the vessel is the 180-ton collier brig *Betsy*, built in Whitehaven. The following chapter discusses the *Betsy* in detail.

44YO89: This site, lying within 15 feet of YO 88, was also completely buried and was only briefly investigated. One exposed section of the hull revealed frames measuring 9 inches square, with 2-5 inch spacing between. Ceiling measured 2 inches, while outer planking at that point measured $4^1/_2$ inches, suggesting that the timber was a lower wale. It is the well-preserved remains of a transport of approximately 350 tons, probably the *Diana* (327 tons) or the *Sally* (330 tons).

44YO222: Little is known about this site, since it lies in deep water near the bottom of the York River channel where diving conditions were too hazardous to permit an extensive survey. The wreck was located in 1980, during field operations conducted in cooperation with a dive team from the British Army's Royal Electrical and Mechanical Engineers. The brief investigation revealed that the site is almost completely buried except for the eroded surfaces of numerous rows of wooden casks. Although no estimate of size could be obtained, this vessel must be one of the transports, probably sunk by Allied cannon fire.

Summary of the Yorktown Shipwrecks

Sufficient information was recorded from the Yorktown shipwrecks to produce an accurate, but incomplete, picture of the surviving hulls. Much of the success of the Yorktown Shipwreck Archaeological Project resulted from the strategy of combining solid, scholarly historical research with high-quality underwater archaeological excavation methodology. From the beginning the project was a multi-disciplinary one, utilizing the knowledge and experience of experts from a broad range of specialization, including archaeology, historiography, geology, naval architecture, and many others.

The most obvious characteristic of the Yorktown transports is their extremely heavy construction and apparently well-constructed hulls. Unfortunately the poor diving conditions and limited staff and funding prevented the recovery of as much data as was desired. However, the unique glimpse of eighteenth century merchant vessels provided by the survey phase of the Yorktown Project was greatly enhanced by the excavation of site 44YO88, as described below and in the following chapter.

The Excavation of Shipwreck 44YO88

In 1979, the project director began planning the complete excavation of site 44YO88, the best preserved of the Yorktown shipwrecks. A major goal was to employ exacting terrestrial archaeological standards by finding a means of circumventing the problems created by the poor diving conditions in the York River. A radical and unique solution was devised and implemented. Based upon Bass's 1976 recommendations and upon subsequent feasibility studies, the excavation was eventually conducted from within a protective "stilling basin," or cofferdam.

The Yorktown Cofferdam

Although the cofferdam concept appeared sound, such a structure had never before been utilized for the underwater excavation of a submerged shipwreck.[7] The cofferdam was to surround shipwreck 44YO88, isolating the entire site from the surrounding river, thus excluding the strong river currents, unregulated powerboats and stinging jellyfish that had hampered previous investigations. The enclosed water, approximately a half million gallons, would be filtered to improve visibility and facilitate excavation.

After an intense and ultimately successful fund-raising effort, followed by a lengthy design phase, construction of the cofferdam finally commenced in March, 1982. The cofferdam, connecting pier and water filtration system were completed by November (Figures 4.13 and 4.14). After a series of technical problems was overcome, average visibility within the cofferdam ranged from 5 feet to more than 30 feet (compared to zero to 3 feet before), depending upon a variety of factors, including the intensity of the excavation, the skill level of the divers, the operation of the filtration system, storms and other, sometimes inexplicable, reasons. The cofferdam greatly enhanced diving conditions, opportunities for photographic recording of the site and, consequently, the quality of the resulting data (Broadwater 1992).

The site also proved to be an ideal training facility. From the very first excavation season, a cooperative research program was conducted each year with the Program in Maritime History and Underwater Research from East Carolina University (ECU), Greenville, North Carolina. The controlled environment within the cofferdam also made it feasible to enlist the aid of scores of volunteer divers, most of whom had little or no archaeological training. The cofferdam offered another unique opportunity, that of public access. Because the cofferdam was easily accessible from shore via a wooden pier, a public interpretation program was maintained at the site throughout the excavation.

The cofferdam was designed and utilized as a tool for underwater excavation; therefore, one of the project goals was to evaluate its effectiveness. Costs and technical consid-

Figure 4.13. Aerial photograph of the Yorktown Cofferdam, showing the work platform, filtration system and airlifts. (Copyright © 1988, Bates Littlehales, National Geographic Society)

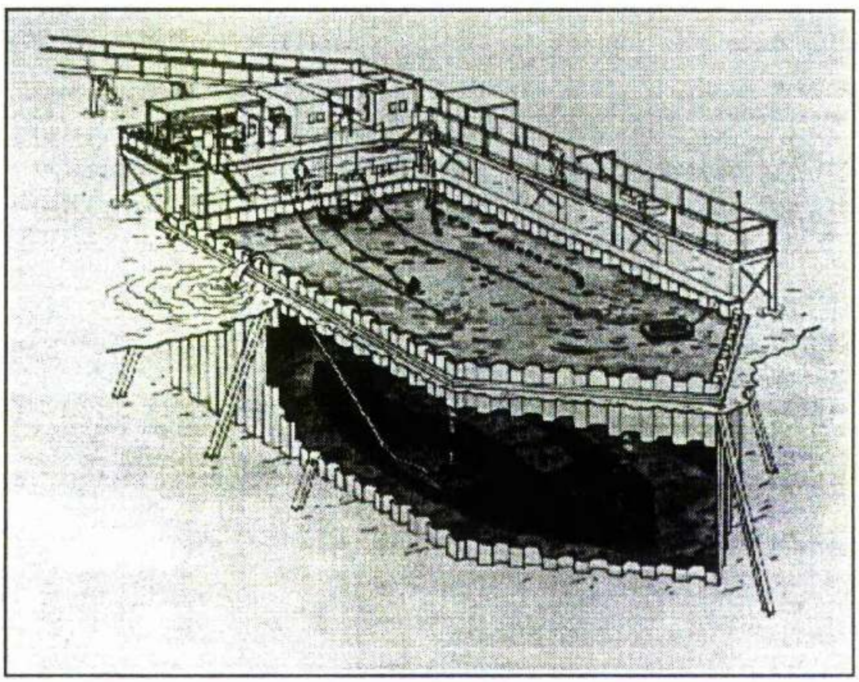


Figure 4.14. Artist's rendering of the Yorktown Cofferdam, showing the shipwreck during excavation. (Copyright ©1988, Piere Mion, National Geographic Society)

erations were matched against such benefits as improved visibility, efficiency, safety and better site preservation with the conclusion that the cofferdam was very successful.

Excavation Methodology

No archaeological site can be properly recorded without accurately-located survey reference points from which to make measurements. Because the cofferdam was a rigid structure, it proved to be an ideal platform for establishing fixed site references. The width of the cofferdam was exactly 45 feet, making it suitable for division into five-foot square units to facilitate horizontal control (Figure 4.15).[2] The reference elevation datum was transferred to the cofferdam from a permanent government survey benchmark at Yorktown.

Sediment removal was accomplished with airlifts, which utilize compressed air to create suction at the intake nozzle. Site overburden thus travelled up the airlift pipe and into the river outside the cofferdam. Care was taken to leave all artifacts *in situ* until mapped; however, a $^{1}/_{4}$.inch mesh bag was clamped to each airlift outflow to capture any artifacts which accidently escaped detection on the site. Divers breathed air from self-contained diving gear (scuba) or air supplied through a hose from an on-site low-pressure compressor.

Although most of the sediment within the hull was fairly compacted and stable, deep trenches with steep walls might have resulted in cave-ins, creating a safety hazard as well as disrupting the stratigraphy, dislocating artifacts and causing loss of archaeological data. Therefore, a "stair-step" pattern of excavation was utilized. Loose upper silt was easily removed by fanning gently with an open hand or brush toward a nearby airlift nozzle. In lower levels, however, sediments consisted primarily of a thick, consolidated grey clay which required the use of trowels.

Mapping of hull components, features and significant artifacts was accomplished through use of a three-dimensional direct-measurement system, using eyebolts attached to the cofferdam as references. Tapes were stretched from each of three (or sometimes four) eyebolts to points to be measured and the tape readings were recorded. The resulting values were converted by microcomputer to rectilinear coordinates (x, y, z) which were then easily plotted onto the site plan. Accuracy was demonstrated to be within +/- $^1/_2$-inch, as long as proper measurement procedures were carefully followed.

Unique stratigraphic features and discrete areas within the hull were given zone designations (Figure 4.16). When the hull or other feature divided a square, each portion was excavated and designated separately. Beneath the upper layer of loose silt (A), the sediments were consolidated well enough to permit stratigraphic profiles to be drawn. When changes in natural strata were observed, notations were made and profiles recorded for use in interpretation.

Detailed mapping and recording was accomplished on a daily basis using waterproof mylar sheets taped to slates on which the grid was superimposed. Sometimes a sheet was drawn for each level of each square; in other situations, recording from two to as many as ten squares simultaneously on larger slates was found to be more efficient. These "mega-slates" were especially helpful in areas where large features or objects occupied multiple squares. An advantage to the use of somewhat standardized mylar sheets is that they provide a permanent record which can be filed and retained.

Following *in situ* recording, cultural material from a given square and level was removed to the surface and stored in containers filled with river water until transferred to the conservation laboratory. Sediment samples and other ancillary specimens, including seeds, shells, wood samples and plant matter, were collected as appropriate. All artifacts and specimens were assigned permanent catalog numbers and logged into a computerized data base.

Initial site preparation and excavation took place in October, 1982, but were cut short by a severe storm. When excavation resumed in early 1983, it was soon discovered that the interior of the hull contained an unexpectedly large quantity of cumbersome timbers and thin planks and boards. These objects lay in a complex jumble, and many could not be removed until excavation had opened a wide, deep pit. Efforts during 1984 and 1985 concentrated on the bow and midships areas. Progress became more rapid during that

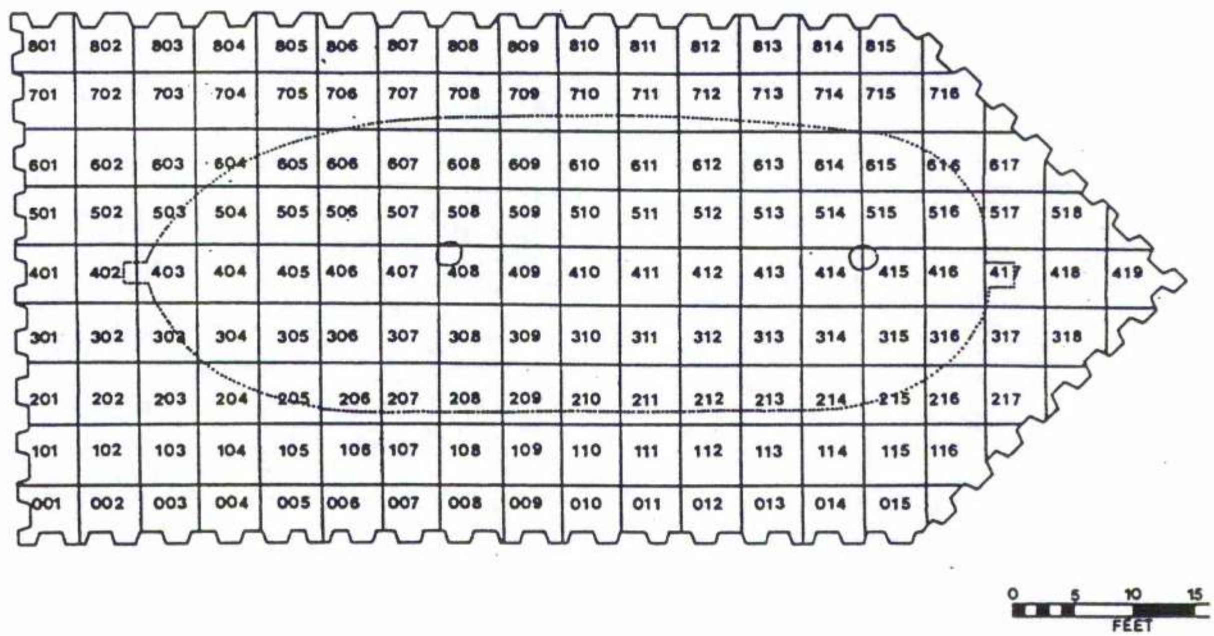


Figure 4.15. Site 44YO88: Archaeological grid designations superimposed on plan view of Yorktown cofferdam (Courtesy Virginia Department of Historic Resources)

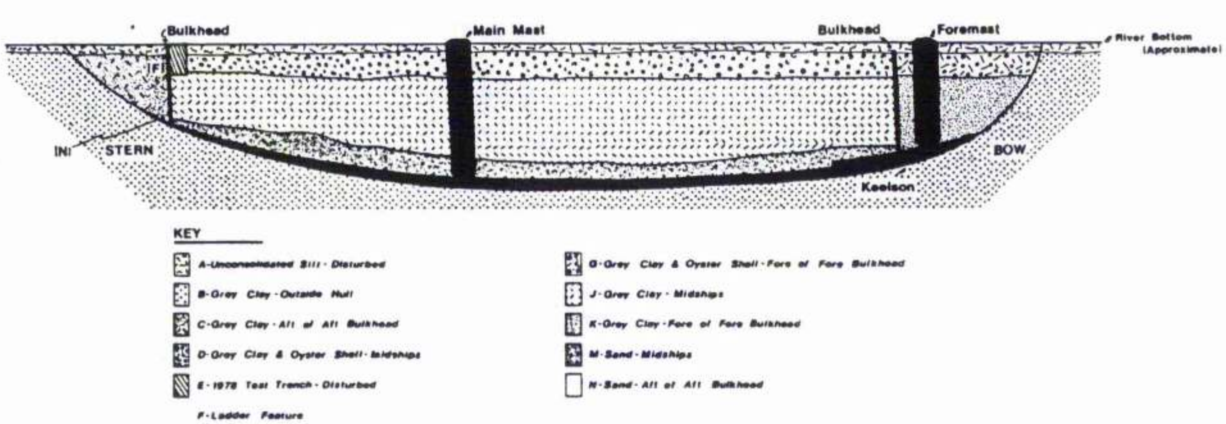


Figure 4.16. Archaeological zone designations shown in a longitudinal cross-section of Yorktown shipwreck 44YO88 (Courtesy Virginia Department of Historic Resources)

period and the bow was completely excavated, along with additional portions of the stern and midships. Forward of a bulkhead in the bow, a variety of boatswain's stores was recovered, including rigging items and cordage, almost a ton of coal, intact and fragmented barrels, and dozens of bark-covered logs. Aft of the bulkhead in the bow, parts of a lower deck were found *in situ* (Broadwater, Adams and Renner 1985).

The stern produced an unexpectedly varied group of artifacts associated with the furniture and furnishings of the stern cabins. Among these items were two panel doors, complete with lock hardware; a companionway ladder; tongue-and-groove panelling with raised molding; components associated with a unique domed-top china cupboard whose shelves were cut with shapes to fit a tea service; a chair arm; two table tops; part of a bookcase; two windows, with intact glass panes; and various types of brass hardware (Broadwater, Oertling and Renner 1988).

Excavation progress was excellent in 1986, despite the need to repair extensive storm damage caused by hurricane Juan in November, 1985. Excavation was conducted simultaneously in bow and stern. A large area in the bow and a substantial section of the stern were excavated, and preliminary hull curvature was recorded to the inside of the ceiling (inner) planking. Approximately three dozen casks were recovered, ranging from a small tar bucket to two very large casks. These casks represent possibly the largest collection of reliably-dated cooperage from the 18th century yet discovered (Shackelford 1988).

Hull Documentation

By 1988, excavation within the hull had been completed. A small volume of sediment on the port side, to port and forward of the mainmast, was left undisturbed for possible analysis by future archaeologists. A trench was cut along the exterior of the vessel, on the starboard side, exposing stem, stern and rudder. The entire starboard side was then accessible for measurement and study. Since ships are longitudinally symmetrical, recording of one side was considered sufficient.[8]

At this point, all ceiling planks were tagged and recorded in detail, to scale. All frames were numbered and tagged, S1-S68 for starboard frames and P1-P66 for port, using plastic labels which provided constantly-visible references throughout the recording process.

In order to properly document hull construction, it was essential to partially disassemble certain hull components.[9] First, all ceiling was carefully removed from the entire starboard side, and from the port bow and port stern areas. The one exception was the thick strake identified as the lower deck clamp, which was left in place for reference and for more complete recording. All ceiling planks were brought to the surface and drawn to a scale of 1" = 1'. Special attention was given to graffiti and construction marks, which were drawn and photographed, then also recorded by rubbing graphite onto onionskin paper overlying the figures.

The decision to completely expose bow and stern timbers was based upon the extremely unusual construction features evident in these areas, as discussed below. Before the lowest bilge strakes were removed, a series of undisturbed sediment samples was recovered from the bilge for analysis.

Then, with interior framing exposed, all frames were recorded in complete detail, including fasteners, molded and sided dimensions, tool marks, chocks, and scarphs. Bow and stern construction details, port and starboard, were recorded in the same manner. Photographs were made to augment manual recording.

The stumps of both masts were unstepped, recovered and recorded. Interestingly, coins were found beneath both masts. A bilge pump assembly, located just aft of the mainmast, was recorded and removed. Then the keelson was completely recorded and partially disassembled. Within limits of accessibility, the keel and deadwood were recorded.[10] On the hull's exterior, sacrificial planking (sheathing) was recorded and removed; then the underlying features were recorded. Samples were taken of the sacrificial planking and the attached felt sheathing material.[11] Wood samples were taken from all hull components, along with samples of barnacle and oyster shells, shipworm tubes and the remains of other organisms found on the wood.

When hull construction had been documented to this level, the next step was to accurately record the shape of the hull. Wooden ships's lines are almost always drawn to the outside faces of the frames. With all ceiling planking removed in bow, stern and starboard side, it was possible to access the edges of the outer faces of all frames, with the exception of the extreme bow and stern areas, where the cant frames were fitted so closely together that few gaps existed. This problem was solved by the removal of a cant frame from bow and stern, which created a sufficient space to permit the necessary measurements to be taken.[12]

Initially, 15 hull stations were recorded using a new device, the Sonic High-Accuracy Ranging and Positioning System (SHARPS).[13] These data were then transferred to a computer-aided design and drafting system (CADD) for generation of hull lines. Due to unresolvable discrepancies in the resulting plots, however, key site measurements were repeated manually and the resulting data used for all subsequent drawing development (Caverly 1989).[14] This painstaking recording provided the data necessary for the generation of a complete set of lines for the preserved hull. Hull data were processed using a computer-aided design and drafting system (CADD). The CADD system not only produced a highly-accurate set of hull lines, but also permitted a detailed analysis of the hull (Caverly 1989).[15]

It must be stressed here that the CADD system was not used to automatically generate idealized hull lines from raw input data. Such systems produce lines which may be representative of the actual hull shape, but are not accurate enough for archaeological or naval architectural purposes. Instead, the CADD system was used as what is sometimes referred to as an "electronic spline," that is, it drew curves based upon operator-controlled reference to the raw data. Final reconstructions and hypothetical lines were developed by the author using traditional manual drafting methods.

Subsequent Analysis

Once the excavation was completed and the analysis had proceeded far enough to ascertain that all necessary measurements had been recorded adequately, the shipwreck was covered with a deep layer of river silt sealed in place with heavy plastic sheeting. The cofferdam walls were then cut off just above the riverbed and the wall sections were placed over the buried shipwreck so as to form a complete steel shield over the site.

In 1990, shortly after 44YO88 had been reburied, a severe budget deficit in Virginia resulted in total cancellation of the state underwater archaeology program, and abolishment of the remaining two state positions in underwater archaeology. That action terminated official state research into the Yorktown shipwrecks. However, the author continued the analysis and interpretation, thanks in part to a grant from the National Endowment for the Humanities which made it possible to enlist the help of more than a dozen experts in various special areas including history, naval architecture, faunal and botanical studies, material culture and geology. The author hopes eventually to publish a comprehensive report on all aspects of the Yorktown Shipwreck Archaeological Project.

In spite of its premature termination, the Yorktown Project generated a wealth of information concerning Cornwallis's fleet at Yorktown, particularly new information on British merchant ships from the eighteenth century. As discussed in the previous chapter, numerous eighteenth-century treatises discuss eighteenth-century wooden vessel design and shipbuilding, often including tables of scantlings, masting tables and occasionally even details on lofting, fastening, etc. However, none of the treatises is supplemented by drawing or sketches of the timbers of actual vessels. Those details can only be provided through archaeology. Shipwreck 44YO88 is described in detail in the following chapter in order to present a highly-detailed example of an actual eighteenth-century merchant vessel.

Notes on Chapter 4

[1] Formerly the Virginia Historic Landmarks Commission, the state historic preservation office in Virginia.

[2] The author located the log book from the transport *Emerald* in the possession of a direct descendent of the Tindall shipbuilding firm that built, owned, leased and operated the vessel.

[3] English units were used throughout the project for consistency with the measurement system by which the ship was built; that same convention will be observed in this study. The symbolic representations for feet (') and inches (") were used for simplicity.

[4] Tonnages for all vessels was estimated by adjusting the dimensions of the extant wreckage, based on an estimate of the extent of preservation and a typical hull form. The adjusted dimensions for length and breadth were then used to compute an approximate tonnage based on the Old Builder's Measure (see Appendix A for more information on tonnage calculation). That the tonnage estimated for GL106 exactly matched that listed for the *Shipwright* is pleasantly coincidental.

[5] As stated above English units have been used throughout this study for consistency with the measurement system from which the ship was built.

[6] Now the Institute of Nautical Archaeology, located at Texas A&M University, College Station, Texas.

[7] Cofferdams were used for excavations of shipwrecks at European locations, including Roskilde, Denmark, and Schleswig, Germany; however, those cofferdams were constructed in very shallow water and the interior pumped dry. The Yorktown Project was the first to use a cofferdam as a "stilling basin" to support an underwater excavation.

[8] Since vessels were constructed by hand, without detailed plans, one would expect slight irregularities in construction; however, constraints of time and budget prohibited consideration of complete hull recording.

[9] By partially disassembling only the starboard side, plus small portions of bow and stern, enough of the hull remains to permit future archaeologists to examine intact portions of the hull.

[10] Time did not permit as much disassembly as desired; however, it is estimated that more than 95% of all hull construction was completely recorded.

[11] Before the invention of copper sheathing, it was common to cover the outer hull below the waterline with tar and then nail on a layer of thin wooden planks, called sacrificial planking, which could be pulled off and replaced after it became infested with shipworms.

[12] Because of the configuration of the cant frames in bow and stern, those stations could not be made perpendicular, but had to be corrected during the analysis process.

[13] The SHARPS system was designed by Martin and Peter Wilcox, who now develop advanced accoustic instrumentation through their company, Marine Sonic Technology, Ltd., White Marsh, VA.

[14] The SHARPS system, initially developed and marketed by Marine Telepresence, Inc., had not been field tested at the time it was used at Yorktown, and it was found that additional testing and software modifications were needed.

[15] Initially, the CADD analysis was conducted on a Prime minicomputer, a large and expensive computer system; however, the files were later exported to AutoCAD and analysis was continued on a desktop PC.

Chapter 5

Yorktown Shipwreck 44YO88, the *Betsy*

At Yorktown shipwreck site 44YO88, the hull itself was by far the most significant artifact. Site 44YO88, later identified as the collier brig *Betsy*, consisted of the intact lower hull of a wooden vessel nearly 73 feet in overall length with a beam of slightly over 23 feet, preserved approximately to its waterline.[1] The hull lay almost on an even keel, with its bow pointing offshore and at a slight downward tilt toward the river channel. When first discovered and surveyed in 1978, the site was almost completely buried beneath protective silt of the riverbed. As the initial site plan (Figure 5.1) indicates, the stumps of two masts were visible, as were a portion of the starboard frame tops, stem and stern posts, the rudder, the upper edges of two bulkheads and portions of the lower deck. (Note: For easier reference and comparison, all hull illustrations are grouped at the end of this chapter.)

Subsequent excavation revealed a very boxy, flat-floored hull, with slack (rounded) bilges and nearly straight sides. The depth of preservation, slightly over 11 feet in the stern and 9 feet in the bow, nearly coincides with the level of the original waterline. Because the starboard side was preserved to a higher level than the port side (due to the slope of the modern river bottom) excavation and recording concentrated on the starboard side. Based upon analysis of the excavated remains, the original dimensions of YO88 would have been:

Length between perpendiculars:	73' $1^5/_8$"
Extreme beam:	23' $7^1/_4$"

Given these dimensions, the tonnage, burthen, was computed to be 176 $^{32}/_{94}$ tons.[2]

The remainder of this chapter describes shipwreck 44YO88 as completely, clearly and methodically as possible. In the following section the hull is described item by item, beginning with the keel and proceeding in the same sequence in which it is speculated that the vessel was constructed. In order to provide a clear and objective description, the analysis and interpretation have been withheld until all hull data are presented. (Reference may be made to the Glossary for definitions of the terms used to describe the hull form and components.)

The Hull[3]

Keel

The keel is 68' $2^{1}/_{2}$" in overall length and appears to have been fashioned from a single oak timber, although one or more scarfs may be concealed beneath the floor timbers (Figure 5.2 and Plate I). (Note: Plate I is an enlarged view of Figure 5.2) The keel measures $14^{3}/_{8}$" sided (width) and $13^{1}/_{4}$" molded (height). The original cross-sectional shape of the keel may well have been $14^{3}/_{8}$" square, since the lower face of the keel exhibits signs of wear. This wear is particularly evident in the bow, just aft of the stem post scarf.

Both heel and head, at the base of the keel, measure only $10^{1}/_{4}$" molded, but whether this is the result of taper or merely wear is unknown. At the heel, at the point where the stem post is fayed on, the keel is once again $14^{3}/_{8}$". No false keel (shoe) could be identified, at least not at the ends of the keel where it could be examined; it seems likely that a shoe had originally been fitted and may, in fact, be partially preserved in the midsection, which could not be examined. Two iron bolts that penetrate horizontally through the base of the keel at 1' 2" and 3' 9" forward of the heel may once have secured a shoe. The rabbet is let into the keel $1^{1}/_{4}$" below the top. At all measurable points this dimension remains constant.

Stern Post

The stern post assembly is fayed to the keel with a shiplap scarf (Figures 5.2 and 5.3). The assembly consists of inner and outer posts, both of oak. The post assembly is raked aft at an angle of 11 degrees from the vertical. The inner post is $14^{3}/_{8}$" molded at the bottom, tapering to 13" at the top of the preserved portion; the outer post is $14^{3}/_{8}$" molded at the bottom and tapers to $2^{3}/_{8}$" molded at its upper extent. Sided dimensions for the outer post are $14^{3}/_{8}$" at the bottom and 12" at the top.

A pine fish plate covering three bolts of $1^{1}/_{4}$" diameter, extends $10^{7}/_{8}$" up from the bottom of the inner post and $6^{1}/_{2}$" down onto the keel. Two bolts penetrate the keel, while the third passes through the post. The fish plate is let into both timbers to protect the bolts that most likely secure a mortise-and-tenon arrangement between the keel and stern post. An oak filler piece, $4^{3}/_{4}$" at the bottom and tapering to $1^{1}/_{4}$" at 3' $4^{3}/_{4}$" up from the top of the keel, is fitted between the inner and outer posts. At the after edge of this fitting, the outer post is $14^{3}/_{8}$" molded. However, it is only $1^{3}/_{4}$" aft of this joint that the outer post steps down $6^{5}/_{8}$" to form the shiplap scarf to the keel. A single bolt of 1" diameter is present $1^{3}/_{4}$" forward of the after edge of the outer post. The outer post is $14^{3}/_{8}$" molded at the bottom and tapers to $2^{3}/_{8}$" molded at the top of the preserved surface. Sided dimensions for the outer post are $14^{3}/_{8}$" at the bottom and 12" at the top. The inner post is the same up to the rabbet; forward of that point, the inner post is $10^{3}/_{4}$" sided.

Between the after edge of the fish plate and the forward edge of the outer post scarf, a pair of scribed lines divide the exposed keel surface. The top line extends from the forward edge of the fish plate to the outer edge of the rabbet. The rabbet is inlet into the inner post $1^{1}/_{4}$" aft of the forward surface. The rabbet is $2^{1}/_{4}$" deep and is vee-shaped at the uppermost, visible, preserved surface. The rabbet rakes aft at a slight angle to the post.

Draft numbers are inlet directly into the inner post.[4] These are scribed Roman numerals with "VII" being the lowest. The bottom line of the "VII" is 6' $10^{3}/_{4}$" from the base of the keel, suggesting that $1^{1}/_{4}$" has eroded from the keel due to the wear already mentioned.) The uppermost preserved number, "X", is considerably smaller than the other three, which are all 8" in height, with their bottom scribes exactly one foot apart. The "X", however, had to be made smaller in order to clear a gudgeon strap, as can be seen in Figure 5.3. In spite of the smaller numeral size, the bottom scribe line of number "X" will be seen to be exactly one foot above the line below.

Stem Post

Details on stem construction are not as complete as those for the stern because of the difficulty in working in a deep trench beneath the bow and because disassembly of the bow was not feasible without additional time and specialized equipment. However, most features of the stem construction were recorded.

The stem post is constructed of two pieces of oak fayed together with two filler pieces interposed (Figures 5.2 and 5.4). The lower segment of the post is fayed to the keel with its aftermost edge 2' $5^{7}/_{8}$" aft of the head. The actual molded dimension of the bottom of this timber is 1' $4^{3}/_{4}$". This section is 10' $2^{3}/_{8}$" in straight-line measurement, with a sided dimension of 1'0" at the top. The bottom is situated $1^{3}/_{4}$" lower than the projected keel top. Securing this union are two iron bands and a fish plate. The aftermost band, positioned 1" forward of the after edge of the stem section, is $2^{1}/_{4}$" wide and extends $14^{3}/_{8}$" from the bottom of the keel, $5^{3}/_{8}$" of which is on the stem post. This band is secured to the stem with three 1" diameter iron bolts. The thickness of the band could not be determined.

A second pine fish plate, located $8^{1}/_{4}$" forward of this band, covers three iron bolts $1^{1}/_{4}$" in diameter, two of which penetrate the stem in the upper 5" of the plate. The plate is 14" in height and terminates at the badly-worn bottom surface of the keel. A seam lies within the inlet recess of the plate, 9" from the top. Between this seam and the bottom of the keel is the third bolt. The scarf arrangement beneath this plate could not be examined since it would have required further disassembly of the stem. A second, longer, iron band is located $2^{1}/_{2}$" forward of the plate. Although this band is also $2^{1}/_{4}$" wide, it is 1' $10^{3}/_{4}$" in length and begins at the bottom of the keel, extending 14" above the bottom of the post. Four bolts of 1" diameter are fastened through the band into the stem and three more of the same size pass into the keel. Forward of this band the head of the keel is only $8^{3}/_{8}$" wide.

The second upper timber in the stem is fayed to the lower timber 5' $4^{3}/_{4}$" above the bottom of the keel. The seam forms a 38 degree angle for a distance of 3' $10^{3}/_{4}$". Of the total length, $10^{3}/_{4}$" is a filler piece at the forward, upper end. A stopwater, 1" x 1" in size, is present at the bottom end of the filler. The upper stem timber is preserved to an elevation of

8' $11^7/_8$" above the bottom of the keel. The width of the stem at the uppermost preserved level, at the after facet, is $11^3/_4$". This piece extends 1' $3^3/_8$" forward and narrows to $9^3/_8$" sided. At this point the timber drops 6" to the lower stem section, forming a step which extends $2^3/_8$" horizontally before terminating with a sided measurement of $8^3/_8$". A second step is formed here with a $10^3/_4$" drop to the gripe. At a point 3' $9^5/_8$ " down the seam between the gripe and stem is a second oak filler l' 6" x $2^1/_4$" in size.

The rabbet continues from the keel up along the two timbers forming the stem at a point 3' $7^1/_4$" from the head of the keel. The rabbet rises in a curve that becomes more acute as it rises, terminating at the top of the post only $1^1/_4$" forward of the after facet of the stem, where it is $2^1/_4$" deep.

The gripe is a solid oak timber with a portion of the cutwater worked into its forward edge. The lowermost end of the gripe, where it joins the keel, forms a puzzling arrangement, as shown in Figure 5.4. A triangular series of grooves is located 2' $2^3/_8$" down the aft edge of the gripe. The wood grain of the gripe continues into the triangle, indicating that both are part of the same timber, with the grooves having been scribed into it. The triangle extends slightly aft of the forward iron band and overlaps the keel by $13^1/_4$". This triangle ends over a $1^1/_4$" gap between the head of the keel and the aft edge of the gripe/cutwater. This gap may have been caused by the wear and tear evident along the bottom of the keel at this point, which gives the impression that the keel is tapering upwards. The damage evident along the keel's sides supports this theory. The gripe/cutwater is $8^3/_8$" wide at the top and $10^1/_4$" at the bottom.

The draft numbers in the bow are also Roman numerals and are scribed in the same manner as those on the stern post. They begin at "VI" and end with "VIII", the highest preserved numeral. All are inlet into the stem pieces. The bottom of "VI" is only 5' 6" from the projected bottom of the keel. Even allowing for wear on the keel, the placement of these numerals suggests the possibility that a false keel originally was present. The bottom line in each subsequent numeral is exactly one foot above its predecessor. The numerals are approximately 7" in height, nearly an inch shorter than their counterparts in the stern.

Hull construction to this point is fairly standard and straightforward; however the arrangement of the transverse timbers and cant frames, to be described next, is unique and previously undocumented for British seagoing vessels.

Stem and stern chocks

A series of unusual transverse timbers is bolted directly to both the stern post and stem post assemblies (Figures 5.2 and 5.5 through 5.8). In the bow these timbers collectively serve the function of an apron. Since no British example of these timbers could be found, the term "apron chocks" was applied. Likewise, the corresponding stern timbers that take the place of the sternson and appear to be a special form of extended lower transoms, have been designated "transom chocks." [5] All chocks are fashioned from oak.

The apron chocks (Figures 5.5 and 5.6) begin $11^{3}/_{4}$" forward of the first floored frame, S61. The lowest chock butts against the deadwood; the remaining chocks follow the curve of the stem directly to the topmost preserved level. There are seven chocks in this arrangement, all of which are unique in shape. (Note that the uppermost chock is not shown in Figure 5.5 due to its almost complete deterioration.) The uppermost chock, designated chock B, is the widest. As the chocks descend, they angle inward to accommodate the cant frame arrangement. The thickness of the chocks, a relatively consistent $9^{5}/_{8}$", was established by probing the gaps between them. Every chock except F is through-bolted with $1^{1}/_{4}$" diameter iron bolts running directly into the stem assembly. Chock F is fastened in place only by treenails. Treenails are also present in the other chocks, but serve to secure the hood ends of the exterior planking. The chocks are slightly curved to permit the bow to sweep aft into the run of the hull. Taken as a whole, this arrangement resembles a segmented apron which extends forward of the first floor.

In the stern, the chock construction technique is almost a mirror image of the stem, with only minor variations (Figures 5.7 and 5.8). Four transom chocks are preserved, all through-bolted directly to the stern post assembly with iron bolts $1^{1}/_{4}$" in diameter. The lowermost chock, Transom D, overlaps the top of the upright portion of the timber assumed to be the stern knee (the timber could not be completely examined without further disassembly of the hull).

Although the general configuration of the transom chocks is similar to that in the bow, the shapes of the stern chocks are quite different. All four angle aft as they ascend but they are much narrower than the bow timbers due to the sharper form of the stern. All four transom chocks contain, in addition to one iron through-bolt each, numerous treenails which secure the hood ends of the planks in the rabbet. The average thickness of the chocks, in both bow and stern, is $9^5/_8$". In the stern, cant frames radiate from the transom chocks, but only two actually abut them. This is a result of the more vertical position of the stern post and the more tapered nature of the chocks.

Deadwood

As can be seen in Figure 5.2, there are several deadwood timbers in bow and stern. In the bow a deadwood timber, DW5, is discernible between the lowest apron chock, G, and the first floor, S61 (Figures 5.2, 5.5 and 5.6). It is 1' 0" in length. The deadwood drops 1' $1^1/_4$" aft of S61 and descends aft at an angle all the way to S47. At S61 the deadwood is $9^5/_8$" thick and still lies over the stempost assembly. At S47, well into the run of the hull the deadwood is 6" thick and rests directly on the keel. The width is consistent with the width of the keel and is $14^3/_8$" throughout. No vertical or horizontal seams are visible. Thus DW5 appears to be a single oak timber.

In the stern the deadwood is comprised of at least five oak segments, including the knee of the stern (Figure 5.2). There are probably additional segments that were not readily discernible with the hull still intact. The uppermost deadwood timber, DW1, starts 1' $4^1/_4$" forward of the lower end of transom chock D and is $14^3/_8$" in width. At this point it steps down 1' $4^3/_4$" onto the horizontal arm of the stern knee, DW6. The knee is scarfed into the after face of transom chock D and extends up behind it for $10^3/_4$".

Only 1' of the knee is visible running downward and there it is secured by two $1^1/_4$" diameter bolts slightly to starboard of the centerline. DW1 runs forward 2' $11^3/_8$" to S11, the aftermost floor timber. One 1$^{1}/_{4}$" diameter bolt is present on the centerline, 7$^{3}/_{4}$" forward of S11. Forward of S11 the deadwood steps down 4$^{1}/_{4}$" and runs to S13. Forward of S13 it steps down again 10$^{1}/_{4}$". Before reaching S15 a vertical seam is visible that extends down 1' 7$^{1}/_{8}$" where it abuts a horizontal seam. The next piece forward, DW2, is 3' 8$^{1}/_{2}$" in length and is also 14$^{3}/_{8}$" in width. It extends from 1$^{1}/_{4}$" aft of S17 to 1$^{1}/_{4}$" forward of S19. It has an angled step-down between S17 and S19 and overlies DW3. DW3 is 15' 7$^{3}/_{4}$" in length, running from S15 forward to S29, slightly aft of the mainmast. It is 14$^{3}/_{8}$" wide throughout. At S15 it is 7$^{3}/_{4}$" thick and tapers gradually as it moves forward to a thickness of 11$^{3}/_{8}$" at S29. DW4 is 5' 5$^{3}/_{8}$" in length and extends from 1$^{1}/_{4}$" forward of S19 to 4$^{1}/_{4}$" aft of S24. At S19 it is 10$^{3}/_{4}$" thick and angles downward as it runs forward where it terminates with a thickness of $^{5}/_{8}$". This piece is also a consistent 14$^{3}/_{8}$" wide.

Framing

Because no midships bend could be identified early in the excavation, frames were numbered consecutively from the stern: S1-S68 on the starboard and P1-P66 on the port (Figures 5.1 and 5.2).[6] The discrepancy between the number of port and starboard frames was found to be in the number of filler frames preserved in bow and stern. The framing of YO88 does not follow the expected pattern. In the after portion of the hull, framing follows a common pattern from fore to aft, with the first futtock always positioned aft of its associated floor. However, the standard convention of reversing the first futtock and floor at the midships frame does not hold true for this vessel; the floor/futtock pattern never changes. Even more unusual, there is no discernible master couple, or midship bend. All of the framing timbers are oak and, while they have well-molded inner and outer surfaces, are sided very crudely.

Close examination revealed that in only seven sets of starboard frames were floors and futtocks bolted together, and those only superficially. The bolted frame pairs are S17/S16, S23/S22, S31/S30, S37/S36, S45/S44, S51/S50, and S57/S56 (Figures 5.2 and 5.9 to 5.14). Apparently, these seven frame pairs, or compound frames, represent the master, or "mold" frames that would have been erected first to establish the shape of the hull. This hypothesis is discussed more fully later in this chapter. The placement of these frame pairs is somewhat irregular. In another departure from tradition, the floors are not bolted to the first futtock even in these paired frames, rather, the bolts fasten the futtocks together above the floors. All the bolts used in these frame sets were $1^{1}/_{4}$" in diameter.

The placement of these mold frame pairs is somewhat ambiguous, exhibiting the following pattern of intermediate, or "filling" frames (Figure 5.2):

Mold Frames	No. of Intermediate "Filling" Frames
S17/S16	
	4
S23/S22	
	6
S31/S30	
	4
S37/S36	
	6
S45/S44	
	4
S51/S50	
	4
S57/S56	

As stated above, with a single exception the floors are not through-bolted to the corresponding first futtock in these paired mold frames. S37/S36 is the only pair with a bolt running through the floor and its first futtock. The other two bolts in this pair secure the second futtock to the first futtock (Figures 5.12 and 5.16).

S17/S16 has three bolts, one of which attaches the second futtock to the first futtock; the other two fasten the second futtock to the third futtock (Figure 5.9). S23/S22 has two bolts attaching the second futtock to the third futtock (Figure 5.10). S31/S30 has three bolts, two of which secure the second futtock to the first futtock; the third fastens the third futtock to the second (Figure 5.11). S45/S44 has three bolts, all running between the second and third futtocks (Figure 5.13). S51/S50 has only two bolts, fastening the second futtock to the first futtock (Figure 5.14). Frame pair S57/S56 has two bolts as well, both securing the second futtock to the third futtock.

Starting in the bow at S61, the first floor, first futtocks S60 and S58 butt directly against the keel and deadwood (Figure 5.2). However, the next first futtock, S56 is offset $10^3/_4$" from the starboard edge of the keel. This offset is carried through on all first futtocks with only minor variations in distance from the keel. This offset ends with S18. At this point S18, S16, S14, and S12 again butt the keel/deadwood arrangement.

As would be expected, the floor timbers are shorter towards the bow and stern with the midships floors extending the farthest outboard before being scarfed to the second futtock. As seen in the illustrations, all futtocks are scarfed with chocks and fastened vertically with treenails, $1^1/_8$" in diameter (Figure 5.15). These scarfs are not uniform in dimension. The futtocks do not line up precisely and are offset on the lower preceding futtock, accentuating the crudeness of the sided dimensions. In the bow and stern floors extensive use was made of fillet pieces (Figures 5.2, 5.9-5.14, and 5.16-5.17). These fillets, in the form of triangular chocks beneath the floors, are present in S61, S59, S57, S55, and S53 in the bow. There are no floor fillets in the relatively flat midships section of the hull. The fillets resume in the stern with S23 and continue aft with S21, S19, S17, S15, S13, and S11. Although these fillets do not, in all cases, fay to the underside of the floors in the vessel's present condition, they may have originally done so. Many of these timbers exhibited evidence of "putrefaction," or dry rot, which occurred while the vessel was afloat. It is likely that the gap observed between the floors and fillets is a result of dry rot, although it is also possible that the gaps were part of the original construction. The fillets are all secured to the floors with oak treenails, $1^1/_8$" in diameter.

In contrast to these fillets in bow and stern floors, top fillets are present on the first futtocks in the center portion of the hull (Figures 5.2 and 5.9-5.14). These top fillets are affixed to the heels of the first futtocks. They provide a smooth curve in line with the upper-sided surface of the floors, to which the bilge ceiling was laid. These top fillets are present on futtocks S54, S52, S50, S46, S44, S40, S38, S36, S32, S30, S28, S26, S24, S22, and S20. Futtocks S48, S42, and S34 do not have fillets, the timber used in these cases being sufficiently thick in the molded dimension. Floor S31 has a small shim, $^5/_8$" thick, attached to the upper surface to ensure a smooth plane for the ceiling.

Each floor and the futtock immediately aft of it were treated as a frame set. A typical frame pattern is depicted in Figure 5.16 and shown in Figure 5.17. Centers were taken from the center of these two members combined, including any space in between. Room and space was calculated for each floor/first futtock and the space aft of this set. Room and space varies from 2' 6" to 2' 1" with an average of 2' 4$^1/_4$".

Cant Frames

The cant frame arrangement on this vessel is a radial pattern (Figures 5.2 and 5.5-5.8). In the bow on the port side, P61, P62, P63, P64, P65, and P66 comprise the cants (Figures 5.5 and 5.6). P61 butts against deadwood, DW5, and is partially fitted against the forward face of P60/S61, the forward most floor. The heels of P63, P65, and P66 are fitted against the apron chocks. P64 and P62 do not butt the apron chocks. P65 has a notch allowing it to fit over the protruding port upper corner of apron chock F. These frames are not fastened to the apron chocks and are so tightly fitted together that no longitudinal fasteners could be discerned. The sided dimensions on these frames seems somewhat cleaner than it does on the starboard frames. Treenails 1$^1/_8$" in diameter secure these cant frames to the planking, with iron bolts, 1$^1/_4$" in diameter running into the frames from the breasthook.

On the starboard side of the bow there is one more cant frame than on the port side. S62, S63, S64, S65, S66, S67, and S68 make up the cant arrangement on the starboard. S63, S65, and S67 do not abut the apron chocks. S62 butts deadwood, DW5, and is fitted tightly against S61 towards the lower end. S66 is notched to fit around the protruding upper starboard corner of apron chock F. As on the port side these frames are held to the planking with 1$^1/_8$" treenails and no fasteners were found either between the frames or between the apron chocks and the frames. Iron bolts, 1$^1/_4$" in diameter were in the frames where they had secured the breasthook. On both the port and starboard sides the two forwardmost frames, P66 and S68 are fitted tightly against apron chocks A, B, C, D and E with their heels resting on the top of apron chock F.

The cant frames in the stern are similar to those in the bow, but are not as radial in their layout due to the sharper curve of the stern (Figures 5.7 and 5.8). Most of these cants butt against deadwood DW1. Only two of the cants actually butt against the transom chocks, P1 and S1. On the port side P1, P2, P3, P4, P5, P6, P7, and P8 make up the cant grouping with P9 being the aftermost floor. P1 is tightly fitted against transom chocks A, B, C and D. P2 is slightly below the lower end of D and is fastened at the heel to the eel of S3 with a treenail. This joint is over the crook of the knee but is not affixed to the knee. P3, P5 and P7 do not reach the deadwood. P4, P6 and P8 are all fitted down to the port edge of DW1. These frames are fastened to the planking with treenails, $1^{1}/_{8}$" in diameter, with iron bolts from the crutch running into the frames. No horizontal longitudinal fasteners were discerned in any of these frames.

On the starboard side, as in the bow, there are more cants than there are on the port side. One of these, S10, is probably present due to the greater depth of preservation on the starboard side. S1, S2, S3, S4, S5, S6, S6, S7, S8, S9 and S10 compose this cant group. S2, S4, S6 and S10 do not reach the deadwood. S3 is butted against P2, and S5, S7, S8 and S9 all have their heels fitted against the starboard edge of DW1. S1 is fitted against transom chocks A, B, C, and D. These frames are all attached to the planking with treenails, $1^{1}/_{8}$" in diameter, and have iron pins from the crutch running into them.

Keelson Assembly

The keelson assembly consists of four components with an overall length of 56' $10^{5}/_{8}$" (Figure 5.2). It rests on and extends from S61, the forwardmost floor, to S13, the floor adjacent to the aftermost floor. It has a consistent width of $14^{3}/_{8}$" and sweeps upward in both the bow and stern. As it sweeps upward it tapers considerably. All upper edges are chamfered to prevent splitting.

The largest component, C, is 50' 4 $^{3}/_{4}$" in length and extends from frame S57 aft to $3^{5}/_{8}$" beyond the after edge of S15. C is only $3^{1}/_{2}$" thick at the forward end which falls in the center of S57. As it sweeps downward amidships it reaches a thickness of 1' $6^{5}/_{8}$" at S31, just forward of the main mast. Here it begins its upward sweep toward the stern and tapers back down to $4^{1}/_{4}$" in thickness at S15. This component is pine, one of the few timbers on the vessel not made of oak.

Fayed to the top of component C is a thin strip of oak, designated component B, which is $4^{1}/_{4}$" thick throughout and is 46' 1 $^{3}/_{4}$" in length. Component A is scarfed to the forward end of B at floor S51 and extends forward 12' $4^{1}/_{4}$" to the center of floor S61. It is secured here by one $1^{1}/_{4}$" diameter iron through-bolt. The forward edges were notched to accept small bilge ceiling planks that covered the apron chocks. At the scarf over B, A is $11^{3}/_{8}$" thick forward of B and $7^{1}/_{4}$" thick at its extreme aft end. A is secured here by two iron through-bolts, both with a diameter of $1^{1}/_{4}$". At the aft end, A is $14^{3}/_{8}$" wide and narrows slightly as it runs forward. S61 is angled to accept it at the forward end. This component is oak and has the mortise for the foremast 4' 6" aft of its forward end. Two iron pins run athwartships through A, one at the corner of the A/B scarf and the other slightly forward of the mortise. Both of these pins are 1" in diameter. The final component in the keelson assembly is D, an oak timber that forms the step for the main mast. D is $14^{3}/_{8}$" wide, 4' 10 $^{3}/_{4}$" in length and 6" in thickness throughout.

The keelson is through-bolted at every floor from S61 aft to S51, with bolts of $1^{1}/_{4}$" diameter. Since component D was not removed, only these frames were actually examined. In all likelihood, however, this pattern continued throughout the keelson assembly's length. Five deck stanchion steps are placed along the keelson assembly, four are on component B and the fifth is on D. The forwardmost stanchion step is centered 4' aft of the after end of A, over S47 and S48. It is composed of two C shaped pieces of oak, each secured by three $^{1}/_{4}$" square-shanked spikes. Although each step varies slightly, all are made up of a pair of C-shaped pieces facing each other and held in place with three square-shanked spikes. The second step is centered 9' 6" aft of the first step and the third, on component D, is centered

9' 6" aft of the second. The fourth step is centered 7' 6" aft of the third step and the fifth step is centered 7' aft of it. The fourth and fifth steps are both affixed to component B.

Lower Deck Structure

Two deck beams and the remains of three lodging knees comprising a portion of the lower deck were found *in situ* in the starboard after quarter, along with other disarticulated deck components (Figure 5.18 and 5.19). The deck beams were set into $1^5/_8$" deep notches in the clamp. All of the deck support timbers are of oak.

The oak clamp is $4^3/_4$" thick on the top with a $9^3/_4$" vertical (sided) dimension. The lower edge was $^5/_8$" in width with a chamfered edge adjoining the vertical surface. The lodging knees that are still overlapped, TT1006 and TT1007 both have wedges fitted into the top of the crook. They are both through-bolted to beam TT1000 in a radial pattern and the remains of a similar pattern were present towards the remains of beam TT1008. The knees are also through-bolted to frames S19 through S29. All iron bolts were $1^1/_4$" in diameter. TT1006, the inner knee, has two notches cut into it to accept a pair of ledges. A single nail is toed into each notch to secure the ledge. These notches are different in size. The forward notch is $4^1/_2$" x $2^3/_4$" and the after notch is $2^5/_8$" x $^5/_8$". Both nails are square-shanked with $^1/_4$" x $^1/_4$" shanks. These notches are $7^1/_4$" apart.

The badly-worn aftermost knee, TT1003, is the outer knee in a pair; the inner knee is missing except for a few fragments. TT1003 is bolted to the frames and shows a radial bolting pattern to the after side of beam TT1004. The remains of one other lodging knee, TT1010, was found disarticulated from the hull, inboard of frames S34, S35, S36 and S37. Only the longitudinal arm of this knee was present.

The deck beams were all badly deteriorated but appear to have averaged $9^3/_4$" square in cross-section. Beam TT1004, the best preserved, was $9^5/_8$" wide by $9^3/_4$" thick, preserved length being 3' $2^1/_2$". Two square shank spike holes are present on the upper surface. The first was 1' $7^1/_4$" from the preserved outboard end. The second was $10^3/_4$" inboard of the first. Both of these holes were $^1/_2$" square.

No articulated lower deck planking was present; however, planks from both decks were found within the hull. All lower deck planks were an unidentified species of pine and measured.

Upper Deck Structure

The hull was not preserved to the level of the upper, or weather deck; however, interpretation of the provenience of deck planking made it possible to identify several 2" thick pine planks from the upper deck.

Exterior Planking and Sheathing

All exterior planking is oak, spiked and treenailed to the frames. This is straight-run planking, $2^3/_4$" in thickness. It rises to the bow with the use of stealers and diminishing hood ends. In the stern the planking runs to the stern post assembly with stealers in the quarter. All hood ends are spiked with $^1/_2$" square-shanked spikes. Liberal use of $1^1/_8$" treenails further secured the ends to the transom chocks and apron chocks.

The hull is covered with sacrificial planking (sheathing) made of pine, $1^1/_4$" thick. This is laid over a felt and tar undercoat. The sacrificial planking is secured with small $^1/_2$" square-shank nails. The sheathing covers the keel, stern post and stem post as well as the hull planking. Draft numbers, identical to the ones in the posts, are scribed into the sacrificial planking. The rudder was also sheathed, although the gudgeon and pintle straps were left exposed.

Main Wale

The main wale assembly, partially preserved along the starboard side of the hull, is composed of three pieces: W1, W2 and W3. A small fillet, preserved below the lowermost strake, W3, gives a smooth lay to the sacrificial planking. All the components of this assembly are oak.

W1 is present from S11 to S49. It is $10^3/_4$" wide and 5" thick. From S11 to S19 it is composed of two pieces running longitudinally with felt caulking in between. Each of these pieces is $2^1/_2$" thick. W2 extends from S8 to S56. It is 1' wide and 5" thick. W3 extends from S8 to S59. Both of these strakes extend beyond the aforementioned frames but have been faired back into the hull at those points. The fillet piece also tapers to a feathered end at those points. At its widest point the fillet is $5^1/_2$"; its maximum thickness is $^1/_2$".

Ceiling

At midships, from the keelson to the lower deck clamp, a limber board and sixteen ceiling strakes were present. The seams, while not caulked, were extremely tight and had no vent spaces or gaps. As the hood ends tapered down in the bow and stern, several strakes were dropped. The ends were bevelled at the point where they met the underside of the transverse bracing timbers. In the stern the strakes ran into the crutch with shorter pieces covering the cants in the lazarette area formed by S11 stepping down to the deadwood (Figure 5.20).

Three short, nearly vertical, ceiling planks were fitted to the forward end of the keelson, where they covered the lower apron chocks. These fitted into the inlet notches on the forward edges of keelson component A (Figure 5.21). All ceiling planking is oak and was secured to the frames with oak treenails, $1^1/_8$" in diameter. Iron spikes with $^1/_2$" square shanks are also present. Similar spikes were also seen in other, apparently random, locations. The seams, while not caulked, were extremely tight and had no vent spaces or gaps. The average thickness of the ceiling was $2^1/_2$", although this varied considerably, particularly where in the vicinity of complex curves.

The ceiling planks featured numerous graffitos and construction marks, as shown in Figures 5.22 and 5.23. The limber strake was composed of 12 sections, 10" in width. These planks were extremely tight and had finger wells on the after ends. At S25 to S27 a collar was fitted around the lower end of the pumpwell. This was spiked to the floors (see pump well section). Other than this collar all the planks in the limber strake were unfastened except for the two on the extreme fore and aft ends. These were secured with two $^1/_2$" square-shanked spikes at each end.

Interior bracing

Only two other transverse timbers survived within the hull (Figure 5.2). In the bow, the lowermost breast hook was still attached, just at the uppermost level of preservation. This timber, shaped from a single crook of oak, measured 12' 6" from end-to-end across its curve. The width at the widest point, slightly to starboard of the centerline, is $14^3/_8$". The breast hook was fitted directly against the frames and bolted into them with a total of seven iron bolts, all $1^1/_4$" diameter. This timber was irregular in thickness, with a maximum thickness of 1' 6". The ceiling planking was bevelled to meet the underside of the breast hook. A small filler was fitted between the breast hook and chock A.

In the stern, an oak crutch, also made of a single oak compass timber, was still attached, just below the level of preservation. The crutch measures 10' $7^1/_8$" from end to end across the curve. It, too, was fitted directly against and bolted to the frames with seven $1^1/_4$" diameter iron bolts. The width of the crutch was 11 $^3/_4$" on the centerline and, again, the sided dimension was crude and uneven, with an average thickness of $11^3/_8$". As in the bow, the ceiling strakes were bevelled to meet the underside of the crutch.

Mast steps and masts

Both the foremast and mainmast are stepped directly into the keelson assembly with simple mortises (Figure 5.2). The masts and masting details are described in the next section, below.

Aft Bulkhead

There were two partially-intact athwartships bulkheads within the hold. The aft bulkhead was composed of vertical planks supported by nailers and horizontal stringers (Figure 5.24). Only part of the bulkhead was preserved, so it was not possible to determine if there was an opening at the level of the lower hold. Because of the rise of the stern in that area, it is possible that access was only from the lower deck which, that far aft, would have been in the captain's cabin. The bulkhead planks were yellow pine.

Forward Bulkhead

The forward athwartships bulkhead, unlike the after one, was constructed of horizontal planks nailed to vertical posts (Figure 5.25). The planks are cut so that their edges align along the post just to port of the longitudinal centerline. This alignment verifies the existence of an opening on the port side; however, the width of the passageway could only be speculated, since no planks survived except for the two lowest, which extended the full width of the bilge, undoubtedly to prevent water and sand ballast from flowing into the forward compartment.

Rudder

The rudder is still shipped, although it is displaced upward 6" and is rotated nine degrees to port (Figures 5.3 and 5.26). The rudder consists of six pieces of oak, with two gudgeon and pintle fittings intact. At the heel the rudder measures 3' 6", tapering to 2' 7" at the uppermost preserved surface. It is a consistent $9^3/_4$" in thickness and the heel is perfectly horizontal.

Rudder component A is the bearding piece, separate from the stock. A is $7^1/_8$" wide at the heel and tapers to $4^3/_4$" at the upper pintle. A is 5' $7^3/_4$" in overall length and is not found above the upper pintle. The bevelled edge tapers from $4^3/_4$" to $4^1/_2$" as this piece goes upward. A also forms the cavity that houses the lower gudgeon and pintle arrangement. The bottom of the lower pintle shaft is butted directly against A since the rudder is upwardly displaced. A serves as a woodlock in this instance and prevents the rudder from being completely unshipped.

The rudder stock, B, is the largest timber in the rudder. It is 1' $0^5/_8$" wide throughout its length. C is $8^3/_8$" wide at the heel tapering to $4\,^3/_4$" at the upper end. D is 9" in width at the heel and 10 $^{3}/_{4}$" wide at the top. A narrow rubbing plank, 2$^{3}/_{8}$ " in width, covers the trailing edge of the rudder. It is slightly rounded on its sides and bottom. Five iron bolts hold the entire rudder assembly together. These bolts are all 1$^{1}/_{4}$" in diameter and run horizontally fore and aft.

The two remaining pintles, made of wrought iron, are located 2' 7" and 6' 4 $^{3}/_{4}$" above the heel of the rudder. The lower pintle was cleaned of all concretion and measured in detail *in situ*. The shaft of the pin is 10$^{7}/_{8}$" in length and 2$^{1}/_{4}$" in diameter. The head of the pintle is 3$^{5}/_{8}$ " in thickness and 4 $^{3}/_{4}$" in length. It steps down to the strap which is 3" wide. The strap angles down slightly as it runs aft. The strap is secured to the rudder with nine iron spikes. These spikes have heads with a 1" diameter and $^{1}/_{2}$" square shanks. The strap for the upper pintle is the same width but has only seven spikes securing it to the rudder. The lower strap is 2' 10$^{3}/_{4}$" in length, the upper strap is 2' 8$^{3}/_{4}$" long.

Two gudgeons are still intact, as is part of the strap of a third gudgeon. The lowermost gudgeon is 5' 0" in overall length and $^{3}/_{4}$" thick. Its strap is 4' 1" long and 3" wide. It is secured by nine iron spikes, three in the post and six in the hull. These are all 1" in head diameter with $^{1}/_{2}$" square shanks. The strap angles upward and bends out to conform to the curvature of the hull. The top of the gudgeon is 2' 6$^{1}/_{4}$" above the heel of the keel.

The second gudgeon top is 6' 2$^{5}/_{8}$" above the heel of the keel and has a strap 3' 10$^{3}/_{4}$" in length. The strap is 3" wide and is secured with nine spikes. These spikes are the same as the spikes in the lower strap, but in this case four are in the post and five are in the hull.

The top of the third strap is 10' 3$^{5}/_{8}$" above the heel of the keel. It, too, is 3" wide and is secured by six spikes identical to the other two sets. Three of the spikes are in the post and three in the hull. This strap is 2' 3$^{5}/_{8}$" in length and also angles upward, bending out forward of the post to conform to the hull.

Pump Well Structure[7]

The three-chambered pump well structure, located just aft of the mainmast (Figures 5.2, 5.27 and 5.28), was constructed in the following manner: a rectangular chock was nailed to the top rider of the keelson to which the spacer boards were nailed such that their outboard sides were flush with the sides of the keelson. Presumably a similar chock was nailed to the underside of the deck to provide an attachment point for the upper ends of the board.

The boards of the fore and aft walls were notched to fit over the keelson/rider assembly and extended outboard of the keelson about 5-6 inches. Each plank was fastened to the side of the keelson/rider assembly with two nails. The fore and aft walls were held in place at the rider keelson by two pieces of quarter-round (2" x 3") placed behind the aft wall and before the forward wall and each nailed into the top of the rider keelson. The six major planks of the well were preserved to a height of *ca.* 5' 7" above the top of the rider keelson. The fore and aft walls were narrower at the top than at the bottom. The segment of lead tube found in the starboard chamber was without a doubt a part of a piston-type pump. The tube was made by forming a flat lead sheet around a circular form and hammer-welding the seam.

The Masts and Rigging

One of the reasons for choosing shipwreck 44YO88 for complete excavation was the discovery of two mast stumps *in situ*, promising to provide information on the rig of the vessel. Not only were the bases of both masts still in place but also, during excavation, other diagnostic rigging items were recovered, making it possible to generate a reasonably accurate reconstruction of the spars and rigging.

Mast Positions

As measured from the projected stern perpendicular, the foremast was centered 61' 6$^1/_4$" forward and the mainmast was centered 29' 9$^7/_8$" forward (Figure 5.2 and Plate I). The locations of the two masts and the relatively small size of the hull suggested a two-masted rig (e.g., brig, brigantine, snow or schooner).[8] However, on three-masted vessels the aftermost mast, the mizzen, was often stepped on a lower deck rather than upon the keelson. In the area of the hull where a mizzenmast could have been stepped, the lower deck had almost completely disintegrated and no mast or mast support timbers, such as a step or partners, were found. Therefore, it was not possible to confirm or rule out the former presence of a mizzenmast. A search for mizzenmast supports, such as chain plates, deadeyes and shrouds, also produced negative results. During the last phase of excavation, both well-preserved mast stumps were unstepped and carefully recorded.

Foremast

The foremast was shaped from an unidentified species of pine. It had no rake (tilt aft), that is, measurements indicated that it was vertical, relative to the line of the keel.[9] The foremast was stepped directly into a simple mortise in the keelson assembly, and wedged tightly into place with wooden chocks.

The stump of the foremast tapered slightly toward its heel, having a diameter of 1' $2^3/_4$" at its upper extent and 1' $2^3/_8$" at a height of 1' 3" above its heel (Figures 5.2, 5.20 and 5.30). At that level, an iron band $2^3/_8$" wide is heat-shrunk onto the mast, presumably to prevent splitting of the base. The mast stump is octagonal in cross section, with facets $6^3/_8$" wide at the highest preserved surface and 6" at the iron band. Three inches below the band, the mast is shaped down to form a tenon which fits into the step. The tenon is $4^7/_8$" wide and 1' $2^3/_8$" long. The mortise is 6" deep on the aft end and $5^3/_8$" deep on the forward end. It is 1' 7" in length, allowing space for chocks to wedge the mast in place. Two oak chocks were present in the forward edge of the step. A heavy residue of pitch was present on the bottom of the step. A silver coin was also found at the bottom of the step but, unfortunately, the coin was too badly deteriorated for identification.

Mainmast

The mainmast, also of pine, was raked aft 1.89 degrees ($1^3/_{16}$ " for every yard of length). The mainmast step was similar to that of the foremast, except that the mainmast was stepped into a short fore-and-aft keelson rider which apparently was installed for that purpose.

The mainmast is virtually identical to the foremast (Figures 5.2, 5.27 and 5.31). Like the latter, it is octagonal in shape, tapers toward its heel, and is fitted with an iron band. The diameter at the upper end is 1' $4^7/_8$" tapering to 1' $3^7/_8$" at the band. The facets measure 7" at the uppermost preserved surface and $6^1/_4$" at the band. The band is 1' 3" above the heel and is $2^1/_2$" in width. Directly below the band, the mast is shaped down to form a tenon measuring $6^1/_4$" wide at the top and 6" wide at the bottom, with a length of 1' $2^3/_8$". The mortise in the keelson is $7^3/_8$" deep, fore and aft, and is 1' $8^1/_2$" long. An oak chock was driven into the forward face of the mortise and an oak shim was wedged into the after face. A small depression within the mast heel held a badly-bent copper coin that, from its size and weight, appears to be an English halfpenny (Figure 5.32). A hole in the coin suggest that it was nailed into place in the heel of the mast and that the iron nail has completely disintegrated.

Standing Rigging

On sailing ships, masts were supported by a complex series of ropes and blocks designed to prevent the masts from shifting to the sides (shrouds) or fore-and-aft (stays).[11] No standing rigging (mast supports such as chain-plates, deadeyes and shrouds) was found attached to the hull. In fact, few items associated with standing rigging were recovered. Figure 5.33 illustrates the distribution of standing and running rigging items from YO88. Most of the

Table 5.1
Standing Rigging Objects

E.R. No.	Quan.	Description	Material
305J09-02	1	THIMBLE	WOOD
306M5-07	1	WORMED LINE	FIBER
310J06-01	1	LARGE SEIZED CABLE	FIBER
315K04-01	2	LINES, SHROUD	FIBER
316G1-01	1	THIMBLE, 3.68" HIGH, HOLE : 1.15"	WOOD
316G1-02	3	ROPE, GOES W/THIMBLE 316G1-01	FIBER
405J14-01	1	THIMBLE	WOOD
406J08-02	1	WORMED AND SERVED LINE	FIBER
406J09-11	1	THIMBLE, IRON	METAL
408M7-01	1	DEAD EYE W/CHAIN PLATE	OTHER
411J06-02	1	TT803 CROSS TREE	WOOD
411J07-05	1	DEADEYE	WOOD
411M1-01	1	DEADEYE	WOOD
411M2-05	1	DEADEYE	WOOD
414A-04	1	ROPE FR WORMD,SERVD GO W/414A-6	FIBER
414A-06	1	DEADEYE 1/2 GOES W/ROPE 414A-1	WOOD
513D2-01	1	DEADEYE 8.5" OD, HOLE: 1.25"	WOOD
614K11-01	1	DEADEYE W/CONCRETION	WOOD
614M2-01	1	DEADEYE	WOOD

rigging items located in the bow were in storage when the vessel sank, while a few were in use.

Nineteen items associated with YO88's standing rigging were recovered, most from the bow (Table 5.1). Two objects were undoubtedly in use when the ship sank: a 7" deadeye in poor condition, with a segment of line still wrapped around it, was found in the upper strata just aft of the foremast; and a 4" wooden thimble that retained fragments of rope around its perimeter and through its hole (Figure 5.34). As can be seen from Table 5.1, a total of four thimbles (3 wood, 1 metal) and eight deadeyes was recovered, one with an iron strap. None of the blocks, stored or active, was stamped or marked in any way.

Alongside these relatively ordinary rigging items was an exceptionally rare and diagnostic component: an intact trestletree assembly, consisting of crossed pairs of trestletrees and crosstrees (Figure 5.35). The assembly was found lying against the forward bulkhead, just to port of the foremast. As discussed below, this assembly contributed very useful information for the reconstruction of the vessel's rig.

Running Rigging

A total of 89 items and dozens of miscellaneous rope fragments associated with running rigging were recovered (Table 5.2). Referring again to Figure 5.33, running rigging (blocks and ropes for manipulating sails and yards) is represented primarily by sheaves, sheave pins and parrel trucks. The softer oak or elm shells of the blocks were apparently destroyed by shipworms, leaving the sheaves and pins, which are made of *lignum vitae*, a very durable hardwood. Outside the bow, two sheaves, connected by a common pin (417B-7), were the only remains of a double block. In all, four blocks were recovered, two of them shoulder blocks. Both shoulder blocks were stored in the forward hold, possibly to be repaired, since one was missing its sheave and pin while the other had its pin but no sheave. Cheek fragments from three additional blocks were also recovered, along with a total of 33 sheaves or sheave fragments. Figure 5.36 illustrates some of the more diagnostic running rigging items.

Table 5.2
Running Rigging Objects

E.R. No.	Quan.	Description	Material
090-78E-SC	2	POSS SHEAVE FRAGS	WOOD
102-78S-2C	4	3 SHEAVES AND 1 PIN	WOOD
115-78E-2C	1	SHEAVE PIN, (AT W&M?)	WOOD
130-78E-2C	1	SHEAVE PIN	WOOD
205B-07	1	1/2 PULLEY CHEEK	WOOD
206D3-03	1	PARREL TRUCK	WOOD
207J02-01	1	PARREL TRUCK, 2.5" O.D.	WOOD
207J02-02	1	PARREL TRUCK, 2.5" O.D.	WOOD
207J02-04	1	PARREL TRUCK, 2.5" O.D.	WOOD
208D2-01	1	PARRELL TRUCK	WOOD
210M1-01	1	LINE W/EYE-SPLICE & WHIPPED	FIBER
212J13-01	1	COIL OF ROPE	FIBER
304D8-02	1	WOODEN PEG, L 2.07" D .73-.77"	WOOD
306D2-01	1	PARREL TRUCK 2.5" DIAM	WOOD
306M5-02	2	BLOCK CHEEKS	WOOD
307J02-06	1	PARREL TRUCK FRAG MEND W/407J2-7	WOOD
307J04-06	1	DOWEL	WOOD
307J04-11	1	PARREL TRUCK, 0.23' O.D.	WOOD
307J06-01	1	PARREL TRUCK FRAG 0.2' O.D.	WOOD
308D1-11	1	PARREL TRUCK	WOOD
309J03-03	1	TT2067 SPAR	WOOD
309J13-05	1	LINE	FIBER
309J13-22	1	ROPE W/PITCH	FIBER
309J13-29	1	SMALL ROPE FRAG	FIBER
309M1-01	1	REEF KNOT	FIBER
312M3-01	1	BLOCK, SHOULDER SHEET	WOOD
315K12-02	4	KNOT (1), AND ROPE	FIBER
402B-06	1	SHEAVE PIN	WOOD
402B-18	1	SHEAVE, HOLE NOT ROUND	WOOD
403C02-02	4	SHEAVE PIN, FID PT, 2 PEGS	WOOD
403C02-08	9	ROPE FRAGS	FIBER
403C08-10	2	SHEAVE PINS	WOOD
404J06-24	1	SHEAVE PIN	WOOD
405D1-04	1	SHEAVE SPINDLE W/NOTCH	WOOD
405J09-14	1	ROPE W/ KNOT	FIBER
406D3-05	1	SHEAVE PIN	WOOD
406J01-05	1	SHEAVE	WOOD
406J10-12	1	SHEAVE HALF	WOOD
406J11-10	1	SHEAVE	WOOD
406J11-14	1	PARREL TRUCK .21' OD	WOOD
406M1-14	1	SHEAVE PIN	WOOD
406M2-06	1	SHEAVE PIN	WOOD
407J02-07	1	PARREL TRUCK FR, MENDS W/307J2-6	WOOD
407J05-02	1	SHEAVE PIN	WOOD
412J07-01	1	KNOT, ROPE FRAG	FIBER
414J09-01	1	BLOCK, SINGLE-PIECE CHEEK	WOOD
414K07-03	1	ROPE HANDLE (KRINGLE)	FIBER
414M3-06	1	COIL OF ROPE	FIBER
414M3-09	1	ROPE, COIL W/LASHING	FIBER
414M3-11	2	ROPE, KNOTS	FIBER
414M3-15	2	ROPE FRAG (OR SQUARE 514)	FIBER
414M3-16	1	SERVED EYE	FIBER
415K07-01	1	SHEAVE FRAG	WOOD
415K11-01	1	ROPE W/CANVAS: SAIL W/BOLT ROPE?	FIBER
415K12-03	1	BLOCK STRAP	FIBER
415K12-06	3	3 SMALL ROPE FRAGS	FIBER
417B-07	3	2 SHEAVES W/PIN CONNECTING	WOOD
504J07-24	1	BRAIDED ROPE	FIBER
504J09-11	1	BLOCK STRAP	FIBER
505J10-01	1	SHEAVE	WOOD
505J10-02	1	SHEAVE	WOOD
505J10-16	3	SHEAVE PINS	WOOD
506A-01	1	SHEAVE	WOOD
506D1-17	1	SHEAVE FRAG	WOOD
506J09-16	1	SHEAVE PIN	WOOD
506J09-19	1	SHEAVE .38' OD	WOOD
506J09-26	1	SHEAVE	WOOD
506M1-06	2	SHEAVES .28' OD ALSO CON 1852	WOOD
506M1-23	1	SMALL SHEAVE	WOOD
506M1-26	1	SHEAVE	WOOD
507J01-02	1	SHEAVE	WOOD
507J02-01	1	SHEAVE & CONCRETION	WOOD
507J02-09	1	SHEAVE	WOOD
507J02-18	1	SHEAVE	WOOD
513J04-08	1	ROPE, COIL AKA CON 169	FIBER
513M3-03	4	ROPE, BRAIDED, W/PITCH	FIBER
515K02-01	1	BLOCK, FLAT TOP	WOOD
606A-06	3	SHEAVE(2), 4.22"&3.97", SHEAVE PIN?	WOOD
606D1-02	1	SHEAVE 4.13" OD, HOLE 1.16"	WOOD
607A-09	1	PULLEY SHEAVE	WOOD
607J02-01	1	PARREL TRUCK	WOOD
609A-02	1	SHEAVE PIN	WOOD
612M1-13	1	SHEAVE FRAG	WOOD
613M1-01	1	SHOULDER BLOCK (W/ROPE 613M1-2)	WOOD
613M1-02	1	ROPE (FROM BLOCK 613M1-1)	FIBER
613M1-14	2	ROPE FRAGS	FIBER
614K09-01	1	LINE W/EYE SPLICE	FIBER
945A-03	2	SHEAVE FRAGS,2.75 & 3" OD	WOOD
SSDS-03	1	SHEAVE PIN	WOOD

The 12 parrel trucks, that allowed the boom and gaff to slide freely along the mainmast, were all found near the surface aft of midships. There were two sizes, 2.0" and 2.5", outside diameter.

Cordage

An impressive variety of cordage was recovered, mostly from the port bow, forward of the forward bulkhead, in what must have been the boatswain's locker. A special form was developed to facilitate the recording and analysis of the cordage (see the sample form in Appendix H). Among the cordage were fragments of anchor cable, coils of hundreds of feet of rope of various sizes, and a variety of knots, splices and surface treatments (Figure 56). Most of the rope, except for the anchor cable, was undoubtedly associated with rigging; however, since almost all of the cordage was recovered from storage areas below deck, it will be discussed in Appendix L along with other boatswain's stores.

Analysis of the Hull and Rigging

Analysis of the Hull

Both historical and archaeological evidence point to the fact that site 44YO88 is the remains of a British merchant ship that had been in service as a naval transport when it was scuttled at Yorktown. That assumption is explored in detail in the Chapter 7. Based on archaeological information alone, however, extensive analysis can be conducted and numerous conclusions drawn. First of all, the hull exhibits relatively heavy construction; frames are relatively large and closely spaced. Bluff bows lead into a full midships section with a moderately fine run aft. With its boxy form and a calculated tonnage of 176 $^{32}/_{94}$ tons, it is convenient to compare YO88 with the 170-ton collier brig depicted in David Steel's *Elements of Naval Architecture* (Steel 1805:plate XXII). YO88 has a projected depth of hold of 9' 10" compared to 10' 0" on Steel's collier. YO88 is also slightly beamier, 23' 7" vs. 22' 11" and shorter by 2' 7" (75' 9" between perpendiculars for Steel's brig vs. 73' 1" for

YO88). The intact remains of the main wale, the top of the sacrificial planking and the draft numbers allow for a reasonably accurate placement of the waterline. The waterline estimate was based on the position of the wale relative to the waterline and upon the fact that sacrificial planking would not likely have been installed far above the load waterline. The projected draft of 9' 6" is 1' 6" less than the draft shown for Steel's collier brig. The broader beam on YO88 probably accounts for this difference. A comparison of body plans shows a remarkable similarity between the two vessels but does not provide an exact match. The bluff bows, full body and fine run aft seen in Steel's collier are, however, readily apparent in the lines reconstructed for YO88 (See Chapter 6).

Moving from the overall hull shape to the individual timbers, the case for classification as a collier grows even stronger. The single-timber oak keel is badly worn along the bottom but was probably 14 $^1/_2$" square when the vessel was laid down. A relatively shallow keel is essential in a vessel designed to sit flat on the bottom, as colliers were. The absence of a shoe, or false keel, seems likely to be the result of damage, since most vessels apparently were constructed with a shoe.[10] However, a British collier discovered and closely examined near Rotterdam, Holland, bears a strong resemblance to YO88 in construction, and its keel shows no evidence of having been fitted with a shoe (Adams, Van Hold and Maarleveld 1990; see also Chapter 7).

The stern post is a two-piece structure with a ship lap scarf to fay it to the keel (Figure 5.2). The outer post rapidly tapers as it rises. Although preservation stops at 10' 2" above the fayed joint it is possible to estimate that this post would only have risen approximately an additional 6". This value was discerned by projecting the seam between the inner and outer posts. The angle of this joint would cause the post to terminate at 10' 8" above the heel of the outer post. At this point a transom arrangement of some type must have been attached and the construction of the stern gallery begun. However, due to the limited preservation, there is no evidence of how this was accomplished. (An attempt at reconstruction will be found in Chapter 6.) The apparent filler piece between the two posts was probably just that, a filler rather than a structural member.

The most unusual construction features are the transverse chocks and cant frames found in the extreme ends of the vessel (Figures 5.2 and 5.5-5.8). Horizontal, transverse chocks fastened to the inside faces of the stem and stern posts are quite different from documented English construction techniques of the day. However, in YO88 they are undeniably an integral part of the framing pattern in the bow and stern. In the bow these chocks serve the function of an apron. Unlike an apron, which was usually composed of two nearly-vertical timbers, the chocks are short, transverse timbers that are not attached to one another. Instead they are individually bolted directly to the stem post and do not make contact with the forward end of the keelson. In the stern the chocks are also fastened directly to the post and are not fastened to each other. Here the chocks form the shape of the lower stern near the post, much the same as transoms and inner stern posts serve that function in more conventionally constructed vessels. These chocks overlap the top of the stern knee where, as in the bow, they butt against a section of deadwood slightly forward of the first floor.

These transverse chocks in a vessel's ends are heretofore undocumented on a British vessel. No previous archaeological work has revealed similar structure in a British oceangoing vessel, nor do contemporary British naval architectural treatises mention this technique. However, research conducted during the present study has revealed that a similar type of transverse chocks frequently appear on plans of eighteenth-century Dutch vessels, particularly a type called the *hoeker*, of which there are numerous plans in the collection of the Prins Hendrik Maritime Museum, Rotterdam. As an example, the profile of a *hoeker* from 1775 clearly shows horizontal bow timbers (PHMM:T471)(Figure 5.37). Another dramatic example is an interior profile drawing lifted from a model at the Prins Hendrik Maritime Museum. The model, thought to be the flute *Houtpoort*, ca. 1700 (PHMM:M211(18); Jobe 1967:85), displays a bow construction strikingly similar to that of YO88 (Figure 5.38).[14] (There are also archaeological examples that will be presented in the following chapter.) Since transverse timbers, particularly in the bow, are not at all rare in Dutch construction, it seems quite likely that Dutch shipwrights felt that transverse bow timbers were the ideal method of forming a bluff bow for a bulk cargo carrier. The similar treatment of the stern may have been merely an experimental extension of the same technique. Since transverse bow timbers were employed on several types of Dutch oceangoing vessels, there is no reason to believe that the method could not have been admired and adopted in English shipyards.

The remaining framing in the bow and stern is also somewhat unusual. Rather than true cant frames that were common by the nineteenth century, YO88 has a radial frame pattern in both bow and stern. This may well be an example of a transitional phase in framing patterns for bow and stern construction. Prior to the use of cant frames (i.e., frames canted off the perpendicular to the centerline in the vessel ends) square frames were run throughout the length of the vessel and the outside molded surface was bevelled to form the shape of the bow and stern.

Cant frames were not mentioned in Thomas Sutherland's *The Shipbuilder's Assistant* of 1711 but they can be found in late-eighteenth century treatises. Few models from the period show cant frames, although a contemporary model of the East Indiaman *Somerset*, 1738 (NMM:1738-1) clearly shows a bow formed of cant frames remarkably similar to those of YO88 (Figure 5.39). Note that gaps between the canted half-frames, as the bow spreads wider, are filled with shorter "chock" cants, in the same manner as the bow of YO88 (Figures 5.5, 5.6 and 5.39). This model is one of the oldest surviving contemporary models of a British merchant ship, and establishes that cant frames existed at least as early as the second quarter of the eighteenth century. Very little is known of the evolution in the design of cant frames that eventually resulted in widespread acceptance by shipbuilders in the following century; however, YO88 is the only vessel excavated to date that has both radial pattern cant frames and short transverse chocks in bow and stern.

Toward the ends, several of YO88's frames make a transition between square frames and frames that angle towards the ends, where the cant frames begin. In the bow the first of these angled frames is the second futtock of S61 (Figure 5.2). As the bow frames continue forward from this point they become cants that abut the short transverse chocks bolted to the stem. The cants do not appear to be fastened to each other or to the chocks. Apron chock F resembles a small floor timber, extending outboard of the chocks above and below it.

In the stern the angled frames begin with the second futtock of S11. Aft of S11 the canted frames have a more standard appearance and butt against the deadwood (Figures 5.2 and 5.7-5.8). Only two stern frames are actually butted against the chocks, these being S1 and P1. Again no fasteners were discernible, either between the frames or from the frames to the chocks or deadwood. This somewhat unusual arrangement warrants far more study to gain a better understanding of the transition from massive square, bevelled frames to the later cant frames with hawse pieces, knight's heads, and fashion timbers. Archaeological remains offer the best opportunity for such further study.

The framing of the vessel is relatively heavy and tightly spaced. The sided faces of the frames are particularly notable, as they are very roughly shaped and uneven, giving the hull a crude appearance (Figure 5.17). Plank-on-frame vessels, as depicted in plans, sketches and models, always show neatly-sawn futtocks whose width tapers gently from keel to top-timbers (Anderson and Salisbury 1954:156-159). Chapelle (1982:276) stated that "the quality of a ship, either in construction or finish, was in accordance to the value of its cargoes; the richness of the trade in which she was employed." Chapelle seems to be suggesting that a hull displaying crudely-finished frames was built crudely and cheaply for hauling inferior cargoes. Conversely, one might assume that "high-quality" merchant ships would have had well-shaped and well-finished timbers throughout. Archaeological and archival evidence to support this hypothesis is scarce. The concept seems significant enough to warrant further speculation. Are crudely-sided frames indicative of poor or hurried construction, or could there be a valid explanation for such a technique?

From a shipwright's point of view, the simplest means of producing futtocks was undoubtedly to cut them to the desired width from unprocessed "compass" timbers using a pit saw, as was common with planking. However, in the eighteenth century this method may have been undesirable, especially in small shipyards. Shaping large futtocks with a pit saw required a large saw frame and extensive shoring and bracing; more importantly, the process resulted in the removal of a significant amount of strength-giving girth and resulted in wastage. At a time when there was a shortage of large compass timber suitable for shipbuilding, small yards may have sought more efficient methods. Possibly, an attractive alternative would have been to quickly trim bark and projections from the sides of the futtocks while leaving as much solid wood as possible.

Obviously, this method was not suitable for compound, or "paired-frames", in which floors and futtocks were fitted and fastened tightly together and fastened to form rigid frames that could be erected as single units. YO88, however, was not constructed in that manner; rather, its master frames were only loosely fitted to each other, and the remaining futtocks formed single frames, offering an ideal opportunity to dispense with carefully-sided frames. Since it was the molded—not sided—faces that determined the quality of the hull shape, it seems feasible that rough-sided frames were quite common. YO88's inner and outer molded faces were expertly formed, providing the proper surface for fair planking and ceiling.

The pattern of floors/first futtocks is particularly interesting on YO88 in that the first futtocks are always positioned aft of their associated floors throughout the hull. Contemprary sources suggest that the conventional configuration placed the first futtock forward of the floor forward of the midships bend and aft of the floor aft of the midship's frame. This convention assumed that the midships bend was double-sided, that is, the floor of the midships bend had first futtocks fastened both fore and aft. Countless exceptions to this convention have been found in the archaeological record, as will be seen in Chapter 7.

YO88 has seven bolted frame sets or pairs. These pairs actually form compound frames and undoubtedly are the mold frames for the vessel. With a single exception, these frames were bolted longitudinally only in the upper futtocks. During construction these frames were probably raised first, following standard English shipbuilding technique. Flexible battens, called ribbands, would then have been fitted to these mold frames and the remaining frames faired into the shape thus created. Another apparent departure from tradition may actually be a quite common technique: it appears that the bilge was planked before all of the frames could be added. The reason for this assumption is that the first futtocks of all but the seven mold frames have no attachment to adjacent frames or to the keel (Figure 5.2). The heels of the first futtocks of those single frames are offset approximately one foot from the keel and are fastened only to the inner and outer planking. Therefore, those frames must have been built up of individual futtocks that were added as more planking was built up. This interesting technique is reminiscent of the "shell-first" techniques of ancient boats and, as illustrated in Chapter 7, represents a convenient timesaving method that precludes the need to loft each and every frame.

Many of the frames incorporate fillet pieces, a practice that is not at all unusual. Fillets were often used to fill gaps created by a flaw in the futtock; they were also used to build up the size of futtocks when appropriately-sized timbers were unavailable. Fillets below the floors provided secure surfaces to which to attach the garboard strake. Those fillets were still in surprisingly good condition. The fillets on YO88 were substantially larger but showed signs of putrefaction (dry rot) along their upper edges where they would have been alternately wet and dry. The lower edges of the fillets, having remained wet, showed no signs of rot. The top fillet pieces on the heels of the first futtocks in midships were present to fill the space left by the use of compass timbers in the frames. The compass timber added strength to the hull and the addition of reverse fillets enabled the bilge ceiling to be laid in a smooth continuous line.

The keelson assembly has several interesting features, the principal one being the use of pine for the main component, C (Figure 5.2). Pine may have been selected for its workability, or because of the lack of a suitable hardwood timber, or possibly it is evidence of subsequent repair. The thin oak strip, B, affixed to the top of C, may have been primarily for extra strength; however, its purpose may have been to serve the same purpose as a shoe on the bottom of a keel. Whether intentional or not, it protected the keel bolt heads and prevented damage to the softer pine keelson. The oak also increased the strength of the entire keelson assembly and provided a hard surface for mount the deck stanchions. The forward section of the keelson, A, is also oak and sweeps upward toward the bow. It contains the mortise for the foremast and secures the forward end of the keelson. Component D is present to provide a strong step for the main mast. The use of several pieces in the construction of the keelson assembly provided both strength and flexibility, two features essential to a vessel carrying a heavy, loose cargo.

Although no deck stanchions were found, the steps for their heels were still fastened to the top of the keelson. The "double bracket" shape of the steps would have allowed the stanchions to be temporarily removed to facilitate the loading and unloading of cargo. This usage was plainly evident from the wear pattern left in the wood's surface. The irregular shape of these pieces and the crude workmanship is indicative of the wear and tear and subsequent replacement these pieces underwent.

The surviving lower deck structure is slightly puzzling in that there was no evidence of hanging knees. Enough of the deck structure survived to conclude with certainty that no hanging knees had been installed. The absence of hanging knees may well be a function of the vessel's original function as a bulk cargo carrier, in which nearly all the cargo was stored in the hold, rather than on an intermediate deck. At least one of the vessel surveys examined in the Deptford Dockyard records complained of a north-country vessel having no hanging knees (PRO, ADM 106/3402:159). The lodge knees were heavily fastened and, at least in the surviving sections, were doubled, indicating that those knees, in conjunction with the substantial deck clamp, were adequate to support the deck structure and to add rigidity to the hull.

The oak bilge ceiling was tightly fitted, with no vent spaces, suggesting that the vessel once carried loose cargo such as grain or coal. The relatively thick ceiling was undoubtedly taken into account by the builder as an additional structural component adding to the strength of the hull. The ceiling covered the chocks in the bow and was bevelled into the underside of the breasthook. In the stern it covered the frames and formed the lazarette, with the deadwood providing the bottom of this area.

Exterior planking was found to be entirely of oak in a straight strake arrangement. This planking is also relatively thick in relation to the vessel's size and, again, would have added considerably to the strength of the hull. The sacrificial planking that sheathed the lower hull was pine, with a thick layer of tar and wool felt between the sheathing and planking. This outer sheathing was intended to protect the hull from the ravages of marine borers such as the teredo worm (*Teredo navalis*). Nail holes in the hull were not discernible, so it was impossible to establish how many times the vessel had been resheathed.

The rudder is fairly typical except that the heel is horizontal rather than swept upward at the after side. Although displaced upward 6" when the vessel settled into the riverbed, the rudder is otherwise preserved exactly as it was during the vessel's active career. The rudder was also entirely sheathed in pine for protection from shipworms. YO88 most likely had a simple tiller affixed at the rudder head in keeping with the simple design and relatively small size of the vessel.

The pump well structure is quite typical and is located just aft of the main mast. The box consists of three chambers with the two outboard chambers extending into the sump of the bilge. The pump mechanism and water discharge spout would have been located on the weather deck. A section of lead pipe, found inside the starboard sump, verified that the pump was a piston-type mechanism. The presence of saw marks across the top end of the pipe and the absence of other pump tubes were apparently indicative of a previous salvage effort.

Analysis of the Masting and Rigging

Determination of the Type of Rig

Regardless of the time period under consideration, sailing vessels are propelled by the harnessing of wind force which is converted to motive power through a complex system of masts, rigging and sails. Oceangoing sailing vessels in the eighteenth century generally were fitted with two or three masts and a variety of sails. The configuration of masts, yards and sails—known as "rig"—was evolving during the latter half of the eighteenth century, creating much confusion and ambiguity concerning the classification of sailing vessels (Goldenberg 1976:77; see also Chapter 1). In the eighteenth century, the terms "ship" and "vessel" were often used interchangeably while, at the same time, "ship" could also refer to a particular type of rig. Not until the early nineteenth century did rig become the primary descriptive criteria (MacGregor 1985:29). No attempt will be made here to discuss the various types of rig, as they are briefly touched upon in Chapter 1 and well described in several excellent references (e.g., Chapelle 1935; Chapman 1768; MacGregor 1985; Steel 1794).

In contrast with the excellent preservation of YO88's hull, relatively little evidence of the vessel's rig survived, probably because those items were quickly salvaged, consumed by marine organisms or carried away by river currents and storms. Therefore, analytical methods had to be employed at the outset in order to attempt a reconstruction of the vessel's rig. Fortunately for this study, various contemporary specifications are available that derive the sizes of most rigging components based upon the size of the masts and spars which, in turn, are determined by the dimensions of the vessel. Even though there is considerable variation among contemporary sources, it was possible to reconstruct YO88's rig with reasonable confidence.

As previously described, shipwreck YO88 was found to have the stumps of two masts—foremast and mainmast—still stepped in place. The placement of the two masts suggests that YO88 carried a two-masted rig. However, the possibility of a third mast deserves additional consideration. Because deterioration of the upper hull made it virtually impossible to determine with certainty whether or not a mizzenmast had existed, the rig had to be deduced through analysis.

YO88's small size suggested from the outset that the vessel was two-masted, since ship-rigged (three-masted) vessels were generally over 200 tons in size in the late eighteenth century, probably because they were not as economical as were two-masters in smaller sizes. Mast position proved to be an important diagnostic parameter in verifying this hypothesis. Modern naval architects position masts in such a manner as to produce what is termed a balanced center of effort. Eighteenth-century shipwrights were familiar with the concept—and the term—but had not developed accurate methods of computing such parameters; instead, masts and yards were selected and positioned according to traditional practice and experience.

Contemporary recommendations and formulae for the positioning of masts are somewhat inconsistent; therefore, a comparison of mast positions on plans and specifications of actual eighteenth-century vessels was deemed the most practical means of developing general trends in mast positioning. Mast positions were measured from plans in Chapman's *Architectura Navalis Mercatoria* (Chapman 1768) for vessels of five different hull types and four different rigs. These vessels were contrasted with known English merchant vessels for which plans are depicted in David MacGregor's excellent book, *Merchant Sailing Ships, 1775-1815*, and from specifications given in Steel's outstanding treatise on naval

TABLE 5.3. MAST POSITIONS ON A VARIETY OF VESSELS

VESSEL NAME OR CHAPMAN PLATE NUMBER	BURTHEN (TONS)	DIST. FROM STERN PERPENDICULAR (%) MAINMAST	FOREMAST	MDSHP FRAME
AVERAGES:				
SNOWS (CHAPMAN)	253.9	37.5	85.2	57.3
(MACGREGOR)	137.0	39.7	84.4	65.2
BRIGS (CHAPMAN)	154.0	36.6	85.2	57.4
(MACGREGOR)	176.3	37.4	85.1	59.9
(DAVIS)		35.5	81.9	
SCHOONERS (CHAPMAN)	154.8	34.7	77.8	56.9
(MACGREGOR)	119.0	39.6	83.2	58.2
SHIPS (CHAPMAN)	345.6	43.4	87.7	57.5
(MACGREGOR)	317.5	43.7	85.8	57.2
(DAVIS, 1-4-6)		42.9	85.7	
SHIPWRECK 44YO88	176.0	41.4	85.3	--

architecture of 1805 (MacGregor 1985; Steel 1805). Charles Davis presents a table for determining mast positions for a variety of vessels including brigs. Unfortunately, he does not cite his sources; nevertheless, his information is included for comparison (Davis 1926:46).

For simplicity of comparison, all measurements were computed as percentages, from the stern, of the length between stem and stern perpendiculars. Percentages were referenced to the stern perpendicular because that reference point is easier to determine with accuracy than that at the bow (Table 5.3).

On YO88, the center of the mainmast was found to be 29.82 feet (41.4%) forward of the projected perpendicular at the stern. The foremast was centered 61.52 feet (85.4%) forward of the stern perpendicular. The above analysis, along with considerations of hull form and size, strongly suggest that YO88 was fitted with only two masts and was rigged as a brig.

<u>Determination of Mast and Spar Dimensions</u>

Mast and spar dimensions were calculated for naval vessels in the eighteenth century according to formulae specified in naval establishments. Merchant vessels, however, did not follow such well-defined rules in determining the sizes of masts, yards and other spars (Murray 1765:46-49). Vessels were sometimes masted according to the builder's (or purchaser's) preferences; at other times, available material was probably utilized, even if it was not precisely the correct size. Even the masts and spars of warships of the same size varied somewhat, according to available materials. Sailing vessels of even moderate size were almost always fitted with masts made up of two or more segments. A lower mast was stepped on the keelson or a deck, and one or more additional segments were attached to lengthen the mast.

Mast and spar lengths and diameters for all types of vessels in the eighteenth century were derived using the length of the lower mainmast as the basis for calculations. That dimension was, in turn, generally based upon the beam of the vessel to be masted. The formulae varied significantly, according to whose criteria was applied, as will be seen in the following analysis.

The stumps of the masts of YO88 provide us with actual diameters: $16^{7}/_{8}$" for the mainmast, $14^{3}/_{4}$" for the foremast, at the level of lower deck. At this level, the masts should have reached their maximum diameter.[12] Contemporary formulae relate mast diameter to length. Therefore, both actual measurements and eighteenth-century formulae were utilized in developing a realistic estimate of mast and spar dimensions.

First, formulae provided in three eighteenth-century treatises were used for computing the mast and spar dimensions for YO88: Using the hull dimensions for YO88 and instructions from Chapman (1768), Steel (1794) and Sutherland (1711), the length of the mainmast for YO88 was computed to be between 47.88 and 69.03 feet long, with a diameter of from 14.36 to 17.90 inches.[13] The actual diameter of the mainmast of YO88 is 16.9 inches, which falls near the midpoint in the above range predicted from contemporary sources. Then, using the same formulae, but working backwards from the known diameter of the mainmast, a predicted mast length of between 50.76 and 65.75 feet was derived.

As can be seen, an attempt to apply contemporary formulae results in a wide range of values for mast size. A compilation of recorded spar dimensions for vessels from this period confirms that in actuality there was considerable variation in mast and spar sizes for vessels of a given tonnage. In addition to the basic formulae, there were obviously other considerations from which builders determined spar dimensions. Among these were the type of wood used for the mast or spar, the service for which the vessel was to be utilized, preferences of the builder and purchaser and availability of materials.

Chapman (1768:95) hints at yet another criterion when he states that "it is not sufficient to study merely to regulate the height of the masts, and the length of the yards, by the size of the ships; but also to use those which have such a proportion among themselves, that all the rigging may make a handsome appearance."

Steel was especially relied upon in determining mast and spar dimensions for YO88. Steel (1794:183) states that "the rigging of a brig is little different from the fore and mainmasts of a ship ...." Using Steel's formulae and the overall measured length and breadth of YO88, all mast and spar dimensions were calculated. However, when calculated dimensions for YO88 are compared with those given by Steel for a 150-ton merchant brig (*Ibid.*:56), the dimensions are quite different. Steel's dimensions were presumably taken from an actual merchant brig that he considered to have pleasing proportions. The discrepancies between Steel's masting instructions and his example brig were not explained in his text.

A final reconstruction of mast and spar dimensions was produced for 44YO88 using a combination of archaeological evidence, Steel's dimensions for a 150-ton collier brig and the various sources mentioned above. Since there is such a small tonnage difference between 44YO88 and Steel's collier brig, it seemed reasonable to rely heavily upon this actual contemporary example.

The trestletree assembly, consisting of crossed pairs of trestletrees and crosstrees, was a particularly important diagnostic find. As can be seen in Figure 5.35, the assembly was found lying against the forward bulkhead, just to port of the foremast, confirming that the assembly was in storage in the boatswain's locker. Its relatively small dimensions indicate that the assembly was to be mounted atop one of the topmasts to support a topgallant mast and shrouds. It may have been a spare unit or may have been taken down for repair or refitting. The trestletree assembly provided valuable information for the rigging reconstruction . Reference to naval specifications reveals that the crosstrees on YO88's assembly are much longer, with respect to the trestletree length, than was recommended (Lees 1984; Steel 1794). This suggests that the shrouds may have been spread further than normal, and that would most likely have been for the purpose of supporting a longer-than-normal topgallant mast. Therefore, the main topgallant mast was increased by $1^1/_2$' in the reconstruction, a change that was deemed appropriate based upon the trestletree assembly and a review of contemporary depictions of this type of rig. In a review of illustrations of colliers from the eighteenth century, Charles McDonald (1984:115-16) found evidence to support this conclusion; he determined from contemporary sketches and paintings that colliers tended to be heavily sparred and to carry relatively long topgallant mast poles.

Such a deviation from naval specifications is not surprising; in fact, a cursory review of merchant vessel spar dimensions suggests a wide diversity, probably necessitated by the many functions for which merchant vessels were built, individual preferences of shipbuilders, and the availability of material. This last factor was becoming more of a problem toward the end of the eighteenth century when masting timbers became more scarce.

Yard lengths for YO88 were kept approximately the same as Steel's brig, with minor alterations based upon Smales's tables (Smales 1959). The driver boom and gaff lengths were increased significantly over those given by Steel, again based upon Smales's masting book and dimensions given for other vessels. The bowsprit and jib boom were also increased slightly.

As described above, the mast and spar dimensions developed for YO88 were based upon available archaeological evidence as well as contemporary vessel descriptions and shipbuilders's advice. The resulting dimensions were used in the development of the sail plan reconstruction presented in Chapter 7.

Standing And Running Rigging

Archaeological evidence of standing and running rigging is limited to a few blocks, an incomplete assortment of cordage items and a few miscellaneous objects. As a result, the description of the vessel's rig has come primarily from eighteenth-century tables and specifications. Reference is made to archaeological evidence whenever possible.

Fortunately for the present study, David Steel's excellent reference work on masting and rigging contains a lengthy table listing all the blocks and ropes required for rigging a brig of 160 tons, just slightly smaller than the 176 tons estimated for 44YO88 (Steel 1794:260-264). From this table, blocks and ropes of each size and type were counted and summarized by computer, providing a complete inventory of standing and running rigging.

It seems incredible that the rigging of even this small, two-masted vessel required a total of 415 blocks and over 8 miles of rope.

Apparently, most of the standing rigging was salvaged soon after the battle or lost through the natural processes of erosion, storms and attack by marine organisms. The dead-eye deposited in the upper strata just aft of the foremast probably held a fore-topmast shroud; the thimble, also found near the surface in the starboard bow, probably supported an upper shroud or stay on the foremast. Two sizes of parrel trucks, all found near the surface of the riverbed just aft of amidships, most likely were associated with the fore-and-aft driver sail on the mainmast. The larger trucks would have held the main boom to the mast, while the smaller ones would have supported the gaff.

Most of the items associated with running rigging were block parts, primarily disarticulated sheaves. The two sheaves connected by a common pin were the only remains of a double-sheave block, and its location in the bow suggests that it may have been from the cat block, used to recover the anchor. Both shoulder blocks were stored in the forward hold. Since both were incomplete, they were obviously being retained for repairs or as spare parts. Most of the cheek fragments, sheaves and sheave fragments were found in upper layers, indicating that they had been a part of the active running rigging. None of the sheaves were fitted with bronze coaks (bushings) and none exhibited identifying marks.

Conclusions

The well-preserved hull remains of Yorktown shipwreck 44YO88 provided significant and extensive information on an English merchant ship from the late eighteenth century. The hull can not be said to be typical of the period, since several of its construction features, particularly the framing pattern and transverse bow and stern chocks, are known from available contemporary information to be unusual. Since so few examples of such vessels are available, one is tempted to speculate that YO88's construction may have been much more common than we now realize. Regardless of several apparent nonstandard features, YO88 is unquestionably one of the most complete and well-documented examples of an eighteenth-century English merchant ship yet located.

The paucity of rigging items precluded reconstruction of the vessel's rig to the same extent as the reconstruction of the hull. Again it was fortunate for this study that it was possible to consult contemporary specifications which detail the size of most rigging components for given ranges of mast and spar dimensions. Following the analysis described in this chapter and the comparative analysis covered in the chapter that follows, the present study attempted a complete reconstruction of the lines, interior arrangement and sail plan for shipwreck 44YO88, and the results are presented in Chapter 6.

Notes on Chapter 5

[1] English units are used throughout the text in order to describe the vessel in the same units of measure that were used by her builders and operators. Parenthetical measurements were found to be too confusing and to break up the flow of the text.

[2] The tonnage formula used for this computation, which came to be called the builder's old method (B.O.M.), was the official standard for computing the tonnage, burthen, of merchant vessels at the time of the American War of Independence. See Appendix A for more information.

[3] The author was intimately involved in all aspects of the survey, recording, analysis and documentation of site 44YO88; however, the author wishes to acknowledge that much of the detailed description and many of the excellent drawings included in the "Hull" section of this chapter were initially prepared by John William Morris III and made a part of his master's thesis at East Carolina University (Morris 1991). The author has rewritten portions of the hull descriptions where appropriate and desirable for the present study.

[4] As described later, the draft markings on the stem and stern posts were covered by wood sheathing; however, the same draft markings were cut into the sheathing.

[5] Professor J. Richard Steffy, Nautical Archaeology Program, Texas A&M University, was kind enough to conduct an extensive but unsuccessful search of plans and drawings in an effort to find a similar structure elsewhere.

[6] If the midship frame, or master couple, had been identified at an early stage of excavation, frames would have been numbered fore and aft of that frame using letters forward and numbers aft in the conventional manner. However, as will be explained, the master couple was not easily determined.

[7] The author wishes to acknowledge that a very detailed report on the construction of the pump box prepared by Thomas J. Oertling provided this description.

[8] See Chapter 1 for more information on contemporary rigs and the Glossary for definitions.

[9] The original field measurements were carefully recorded with a plumb bob and level line, then later corrected to the horizontal plane of the keel.

[10] Definitions of rigging terms are included in the Glossary.

[11] In eighteenth-century terminology, deadeyes are classified as blocks, even though they had no moving parts, and the term "rope," rather than the more modern "line," was standard.

[12] The typical mast increased slightly in diameter from its heel, at the mast step, to a point at or near the lower or main deck, then decreased slowly to its head.

[13] Decimal numbers were used during analysis for ease of calculations.

[14] The Museum Library does not believe this model is of a vessel called *Houtpoort*; in fact, the word means "port in the bow for loading timbers" which suggests that the vessel was a timber carrier and that a descriptive term was mistaken for the vessel's name. The model represents a flute (*fluitschip*) of ca. 1750-1799 (Bouma 1993:pers.comm.)

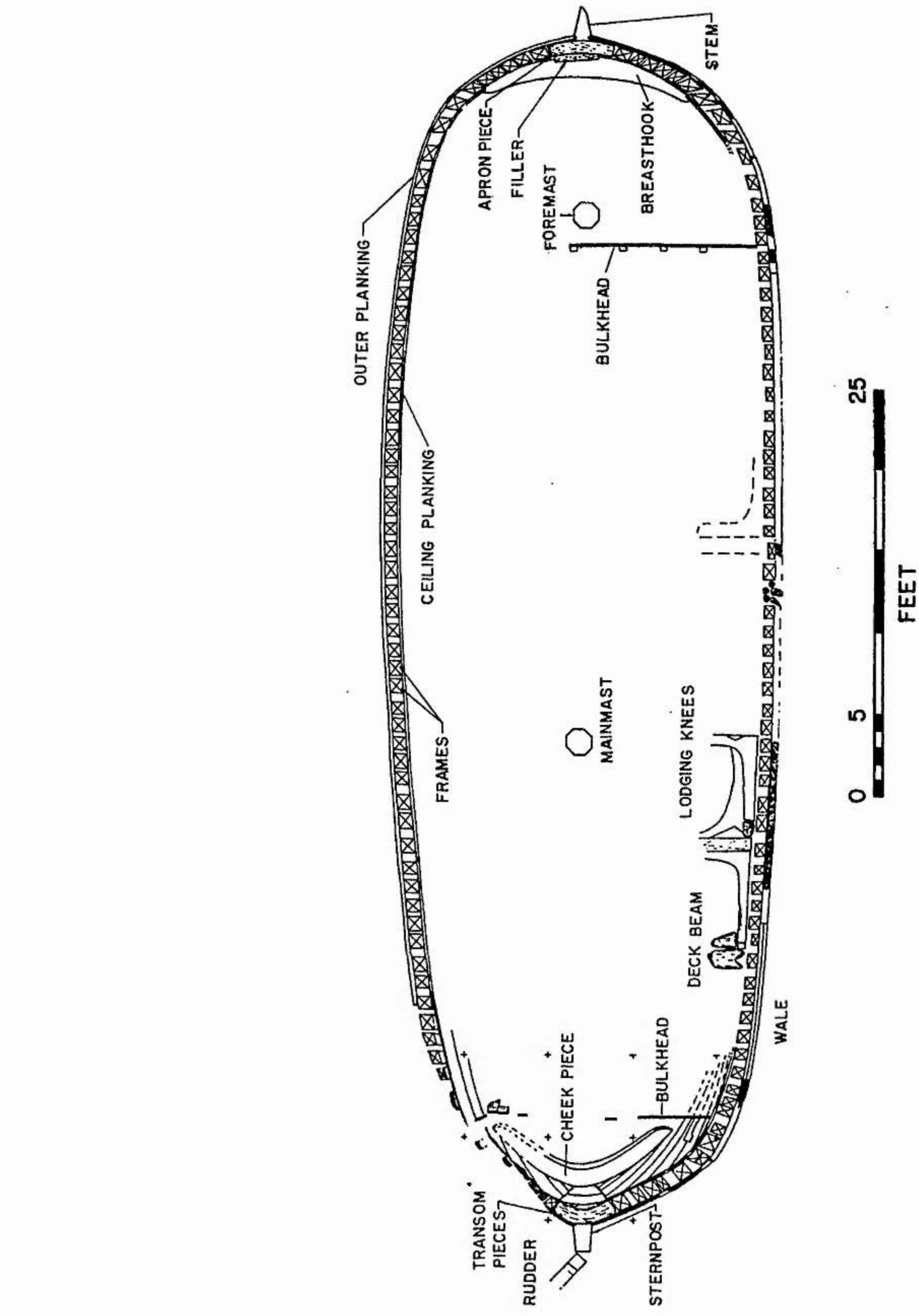


Figure 5.1. 44YO88, Initial Site Plan

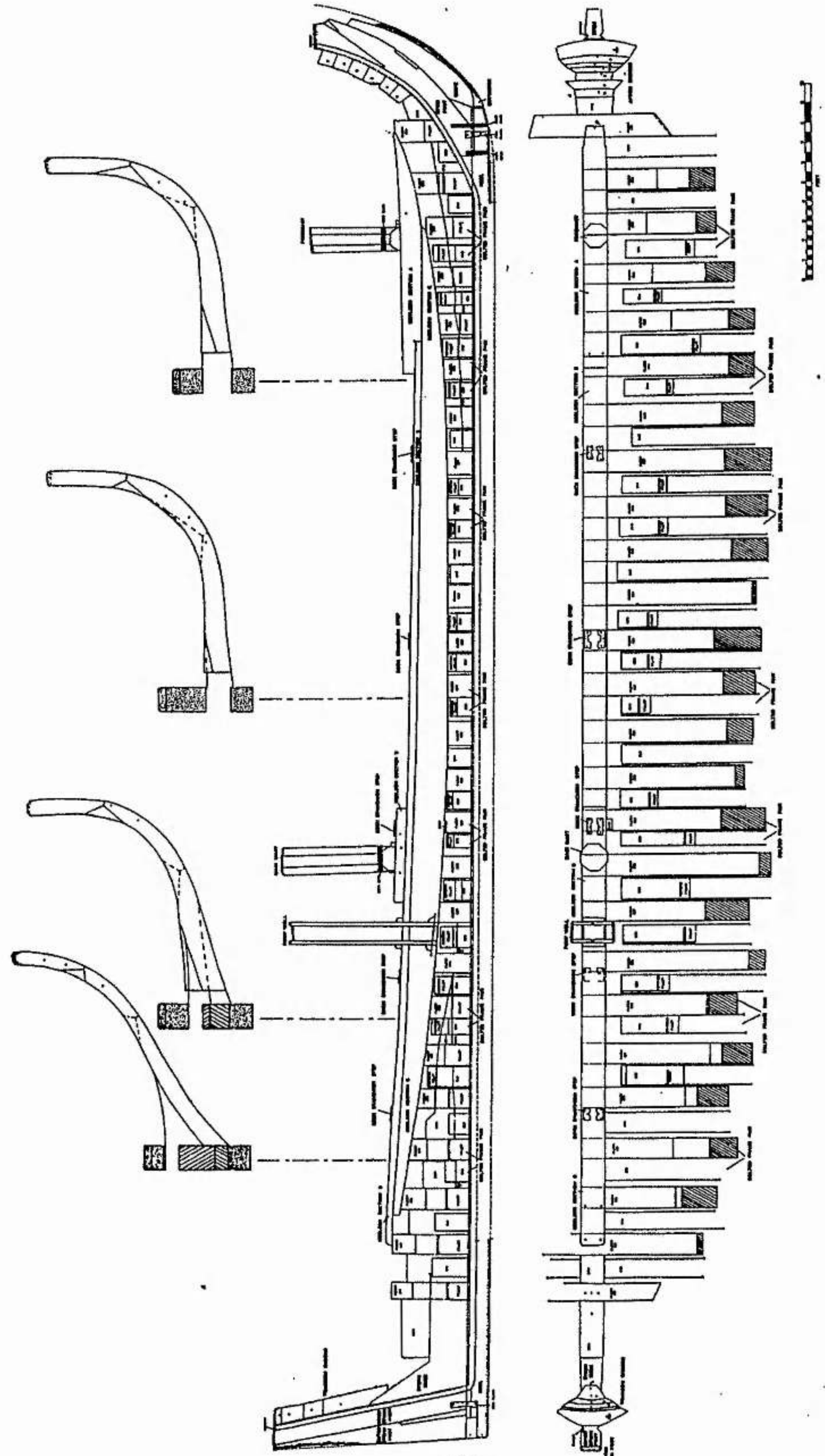


Figure 5.2. 44YO88: Plan and profile, showing prinicpal gimbers (NOTE: See also a larger print on Plate I) (John W. Morris III, Courtesy Virginia Department of Historic Resources)

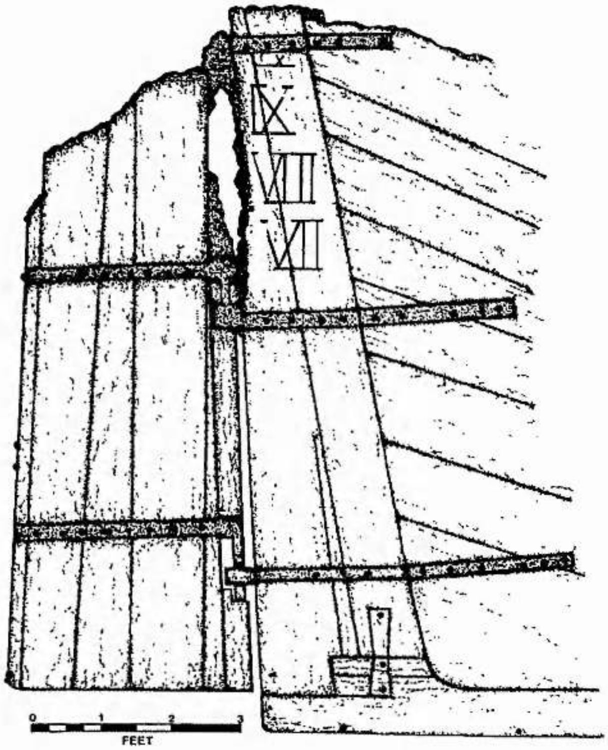


Figure 5.3. 44YO88: stern and rudder, exterior (John W. Morris III, Courtesy Virginia Department of Historic Resources)

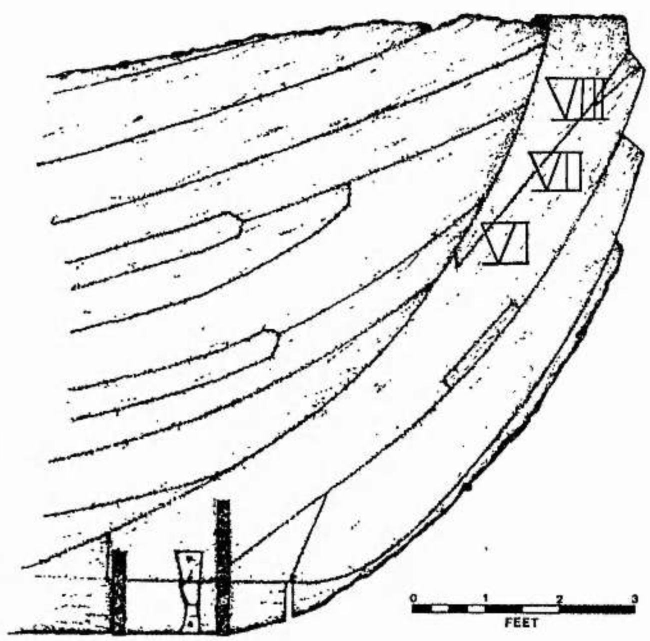


Figure 5.4. 44YO88: stem, exterior (John W. Morris III, Courtesy Virginia Department of Historic Resources)

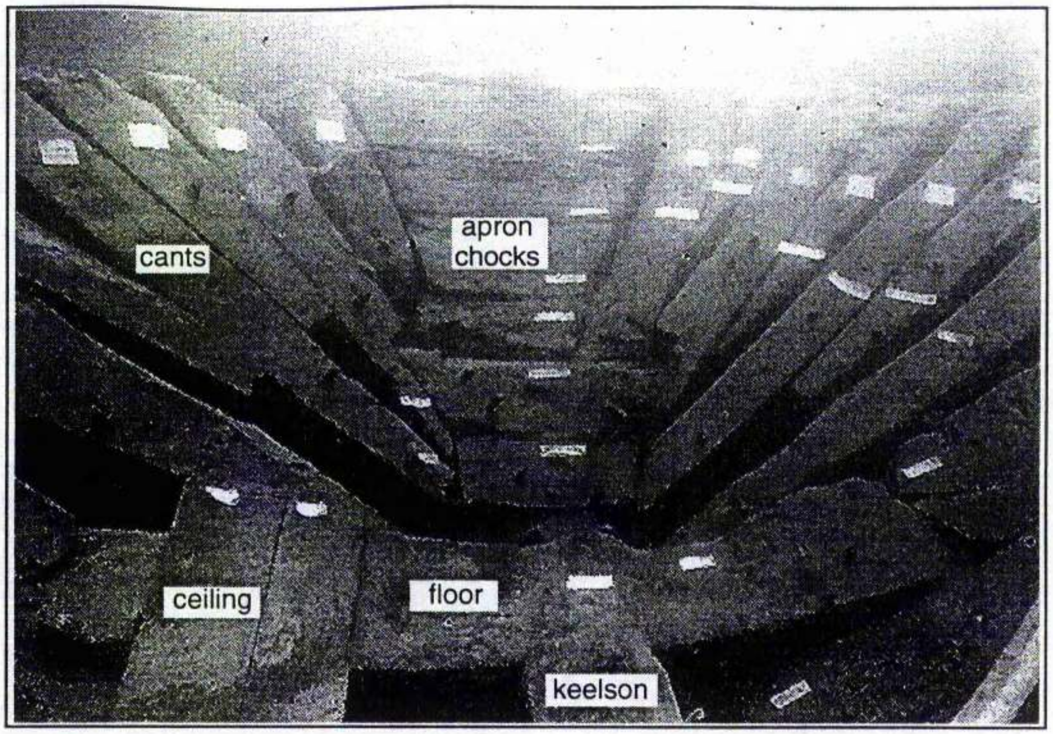


Figure 5.5. 44YO88: Photograph of bow, facing forward, with ceiling and breast hook removed, cants and apron chocks visible (John D. Broadwater, courtesy Virginia Department of Historic Resources)

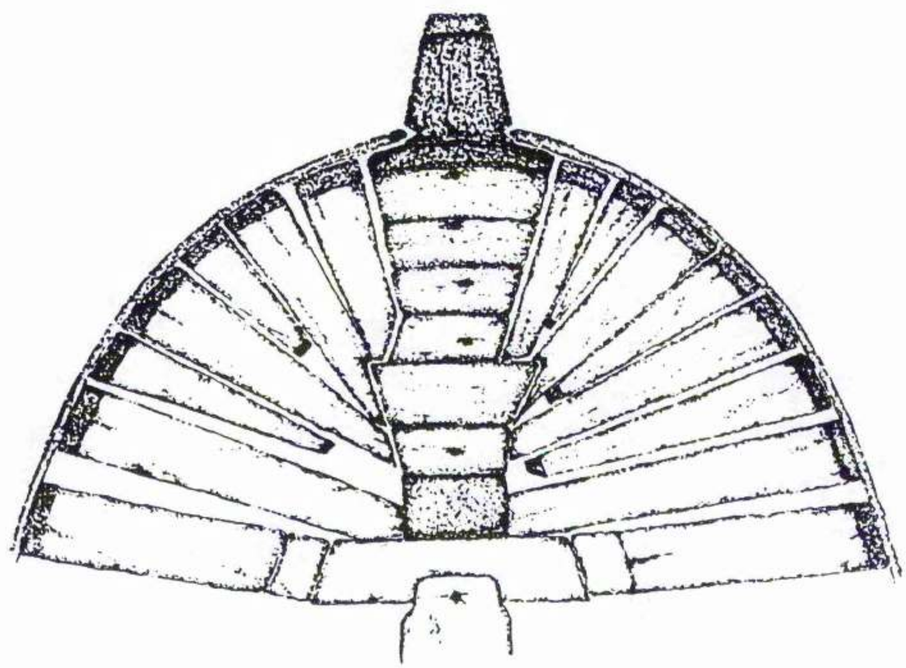


Figure 5.6. 44YO88: Illustration of bow, with framing exposed (John W. Morris III, courtesy Virginia Department of Historic Resources)

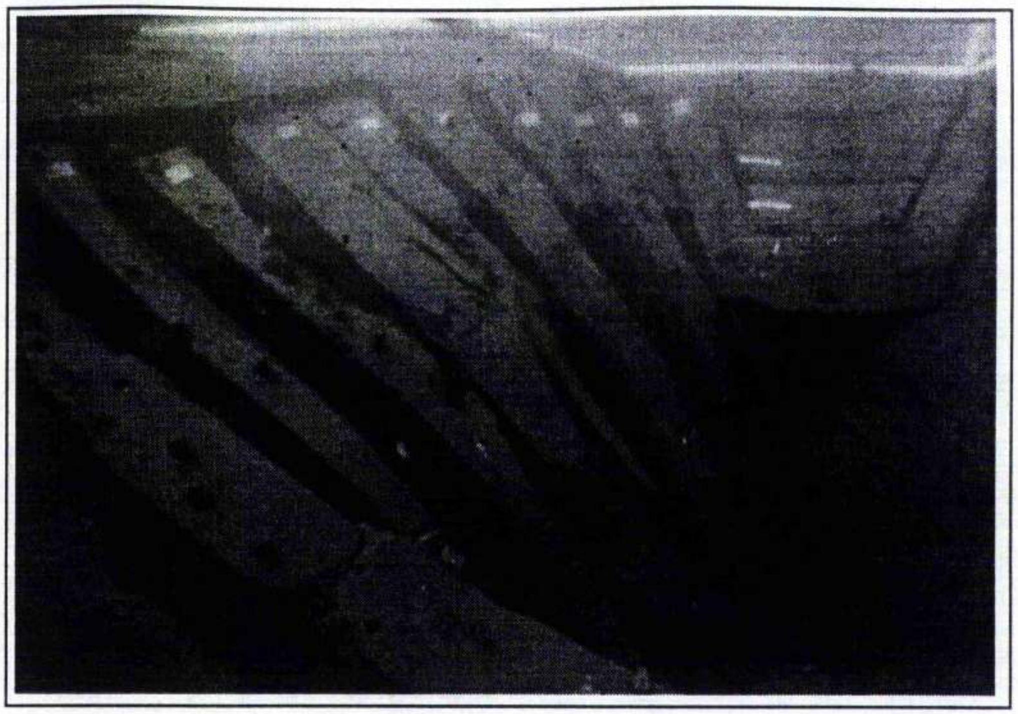


Figure 5.7. 44YO88: Photograph of stern, with framing exposed (John D. Broadwater, Courtesy Virginia Department of Historic Resources)

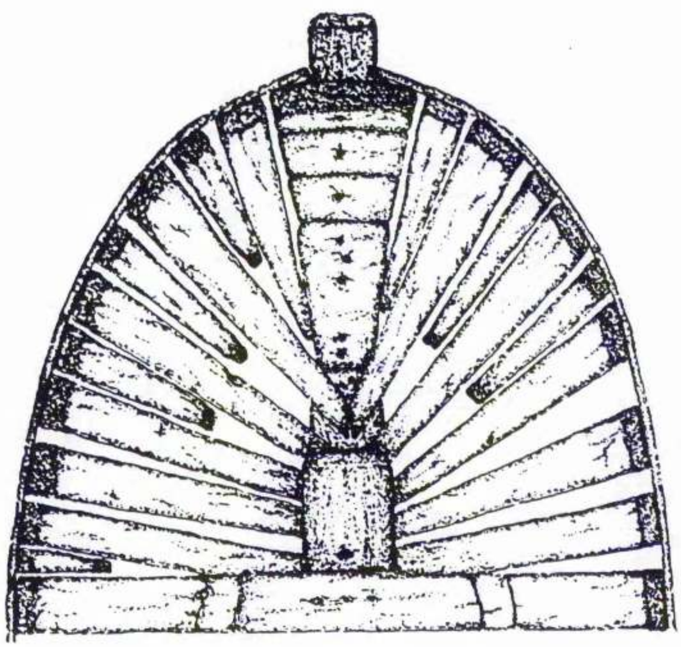


Figure 5.8. 44YO88: Illustration of stern, with framing exposed (John W. Morris III, Courtesy Virginia Department of Historic Resources)

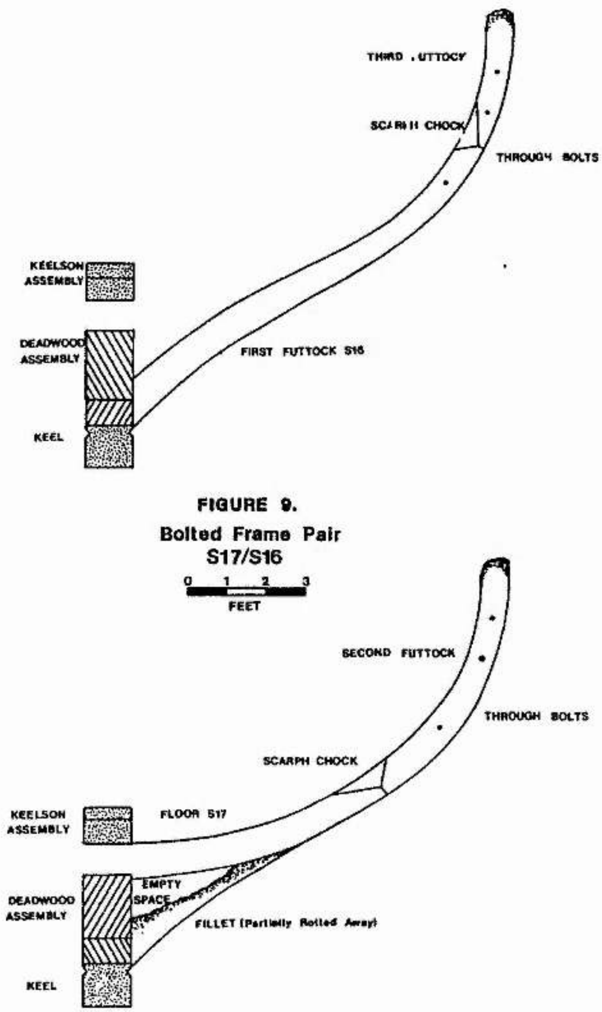


Figure 5.9. 44YO88: bolted frame pair S17/S16 (John W. Morris III, Courtesy Virginia Department of Historic Resources)

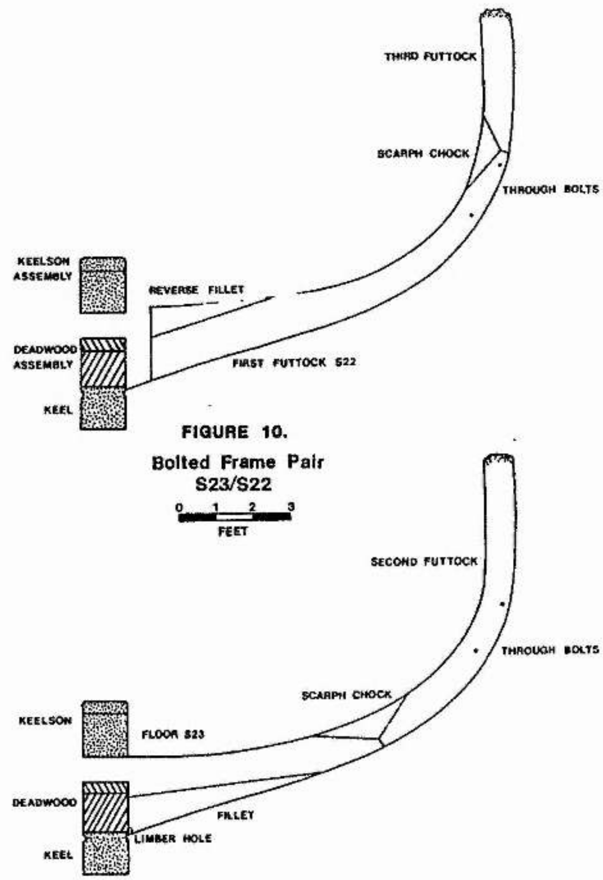


Figure 5.10. 44YO88: bolted frame pair S23/ S22 (John W. Morris III, Courtesy Virginia Department of Historic Resources)

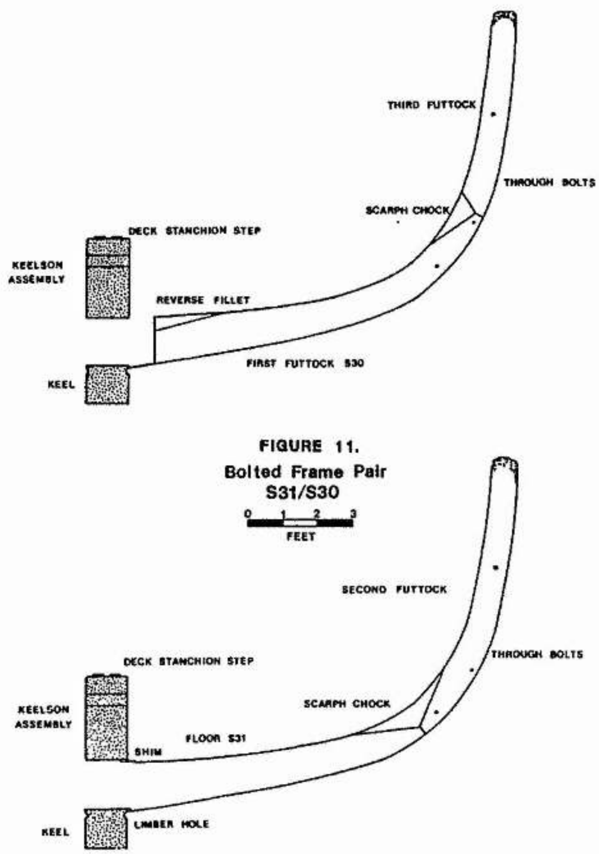


Figure 5.11. 44YO88: bolted frame pair S31/S30 (John W. Morris III, Courtesy Virginia Department of Historic Resources)

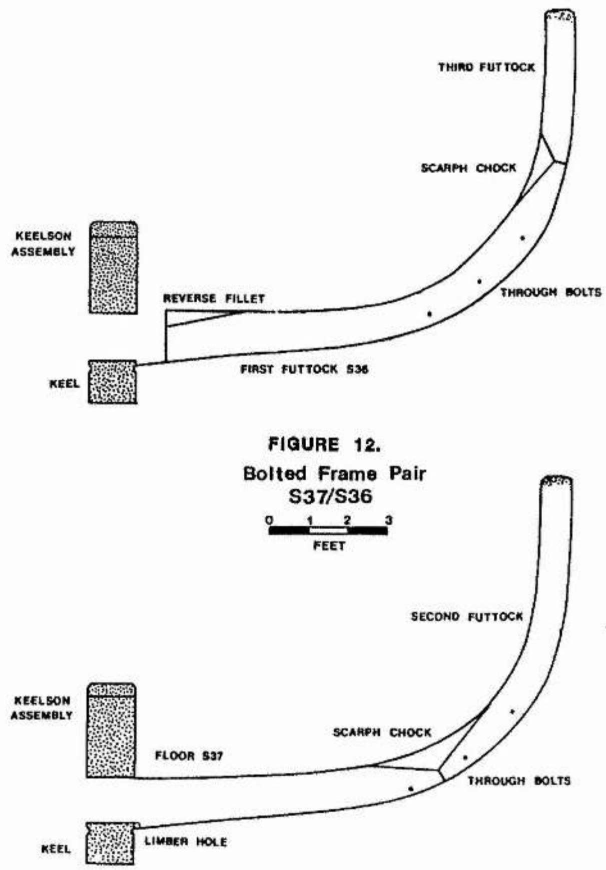


Figure 5/12. 44YO88: bolted frame pair S37/S36 (John W. Morris III, Courtesy Virginia Department of Historic Resources)

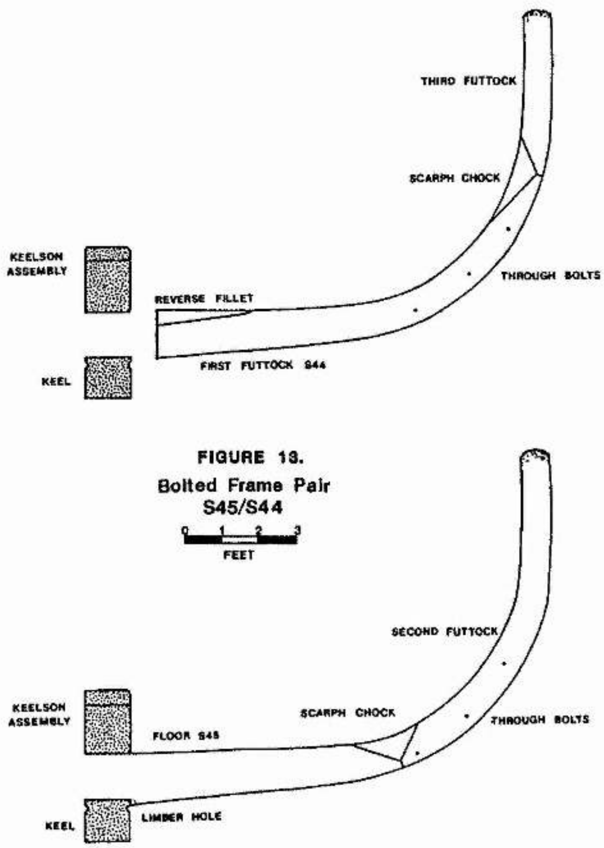


Figure 5.13. 44YO88: bolted frame pair S45/S44 (John W. Morris III, Courtesy Virginia Department of Historic Resources)

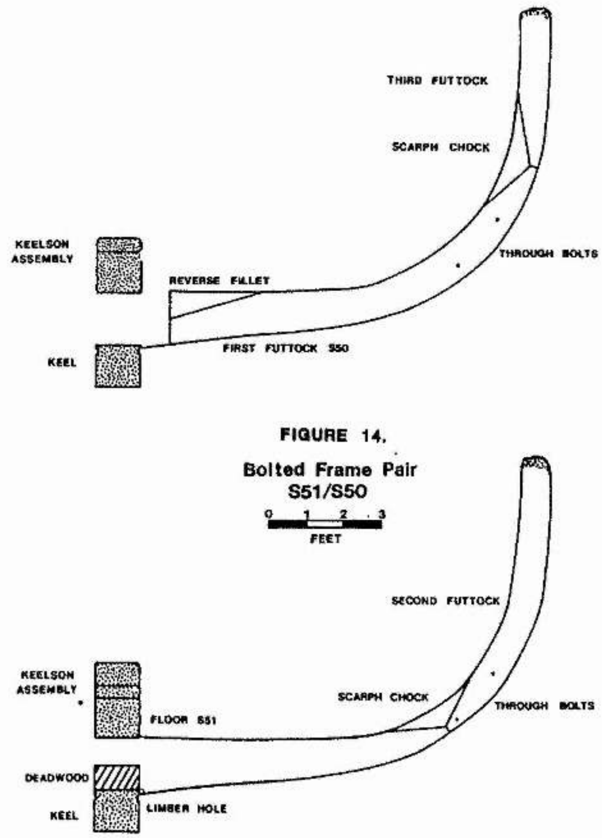


Figure 5.14. 44YO88: bolted frame pair S51/S50 (John W. Morris III, Courtesy Virginia Department of Historic Resources)

Figure 5.15. 44YO88: closeup of triangular frame chock (John D. Broadwater, Courtesy Virginia Department of Historic Resources)

Figure 5.16. 44YO88: typical pattern of mold frames, at midships, with intermediate filling frames omitted for clarity (John D. Broadwater)

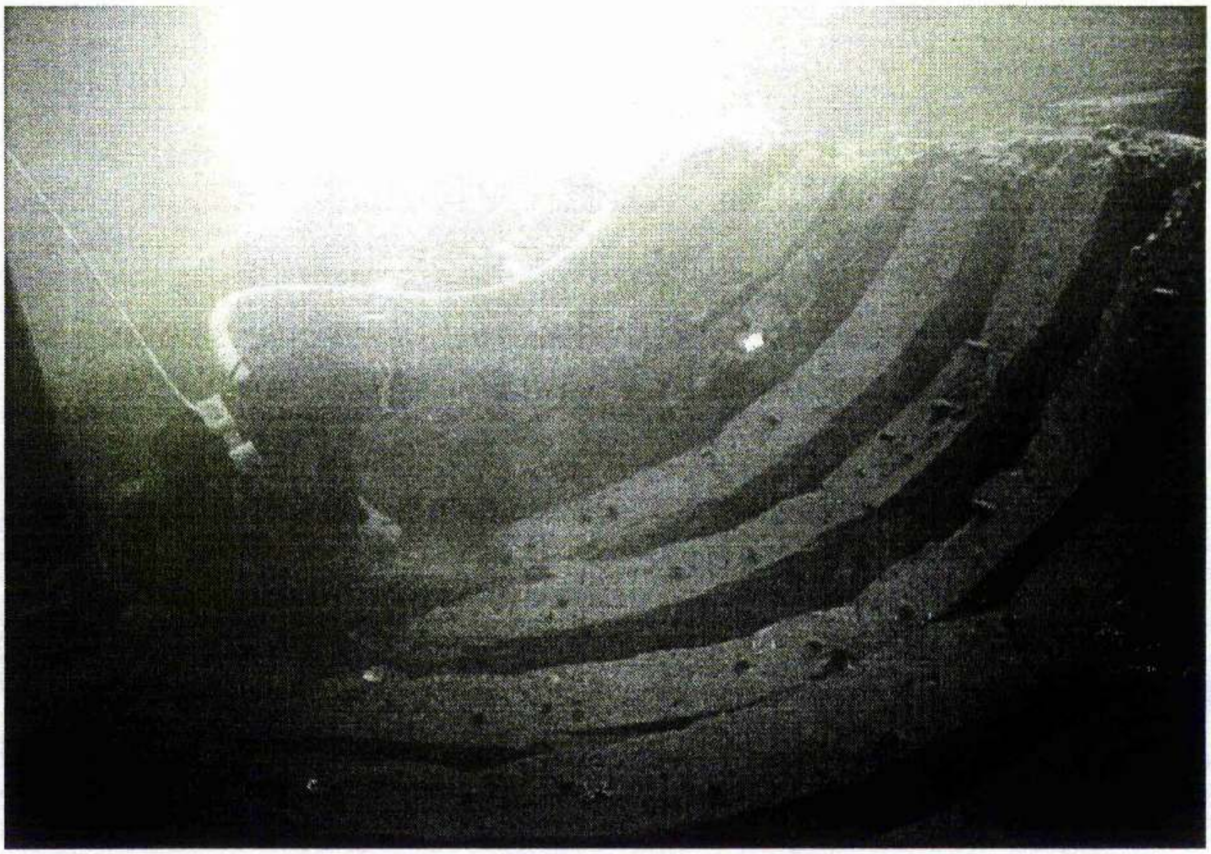


Figure 5.17. 44YO88: midship starboard frames, looking forward (John D. Broadwater, Courtesy Virginia Department of Historic Resources)

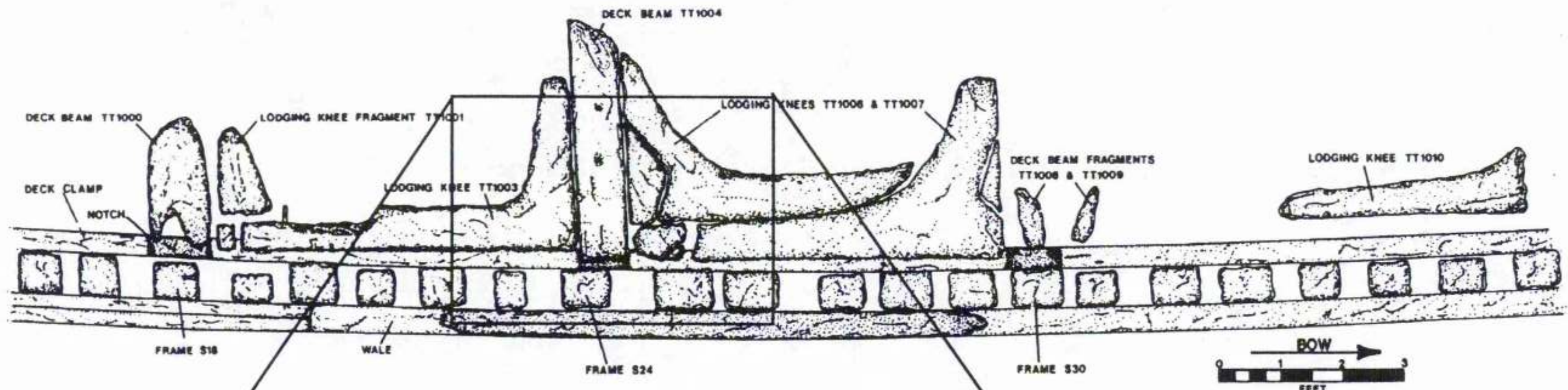


Figure 5.18: 44YO88: preserved lower deck structure (John W. Morris III, Courtesy Virginia Department of Historic Resources)

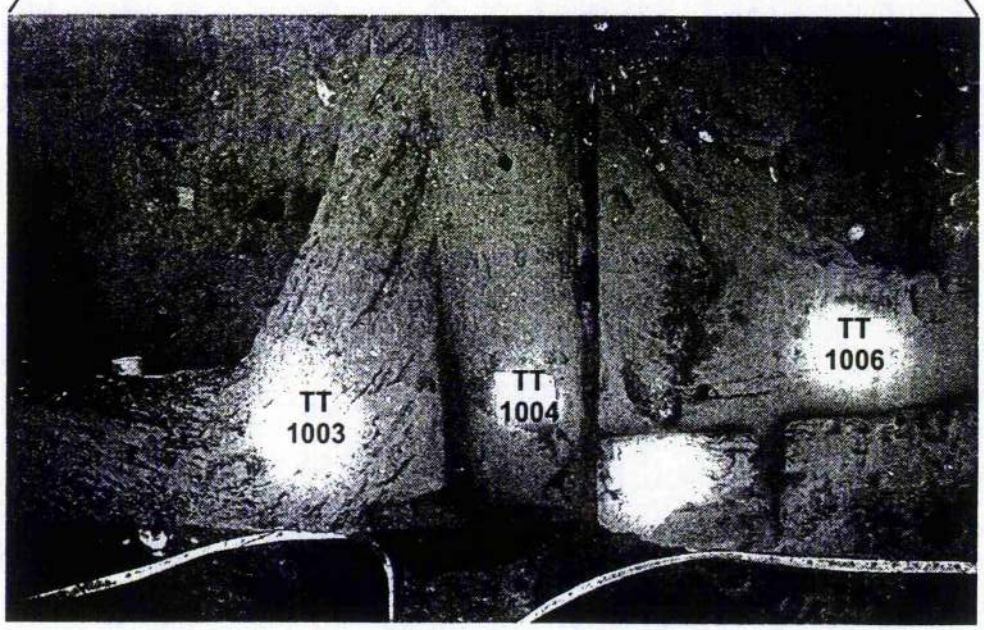


Figure 5.19. 44YO88: photo of preserved lower deck structure (John D. Broadwater, Courtesy Virginia Department of Historic Resources)

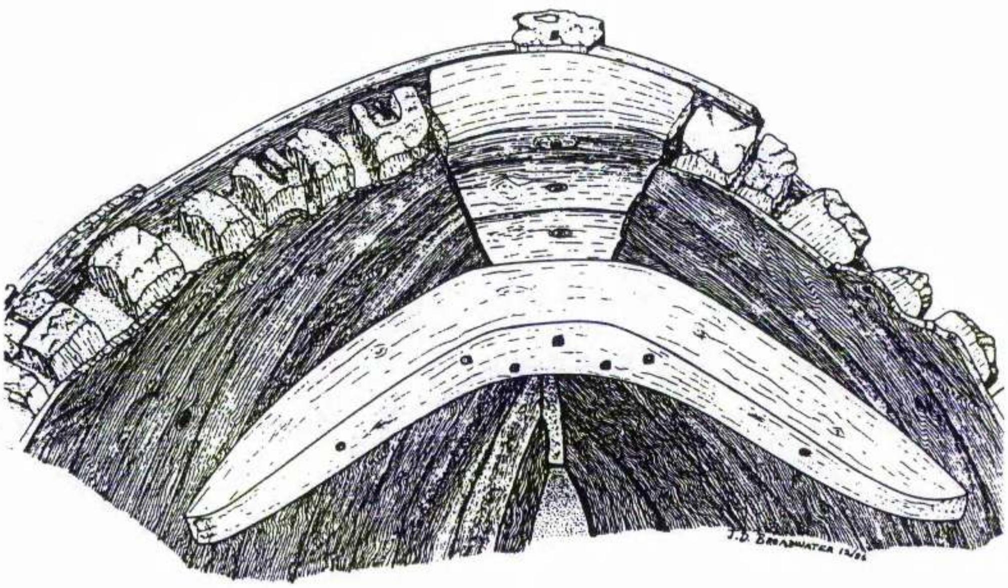


Figure 5.20. 44YO88: stern, before removal of ceiling planking (John D. Broadwater, Courtesy Virginia Department of Historic Resources)

Figure 5.21. 44YO88: bow, before removal of ceiling planking (Kevin Crissman, Courtesy Virginia Department of Historic Resources)

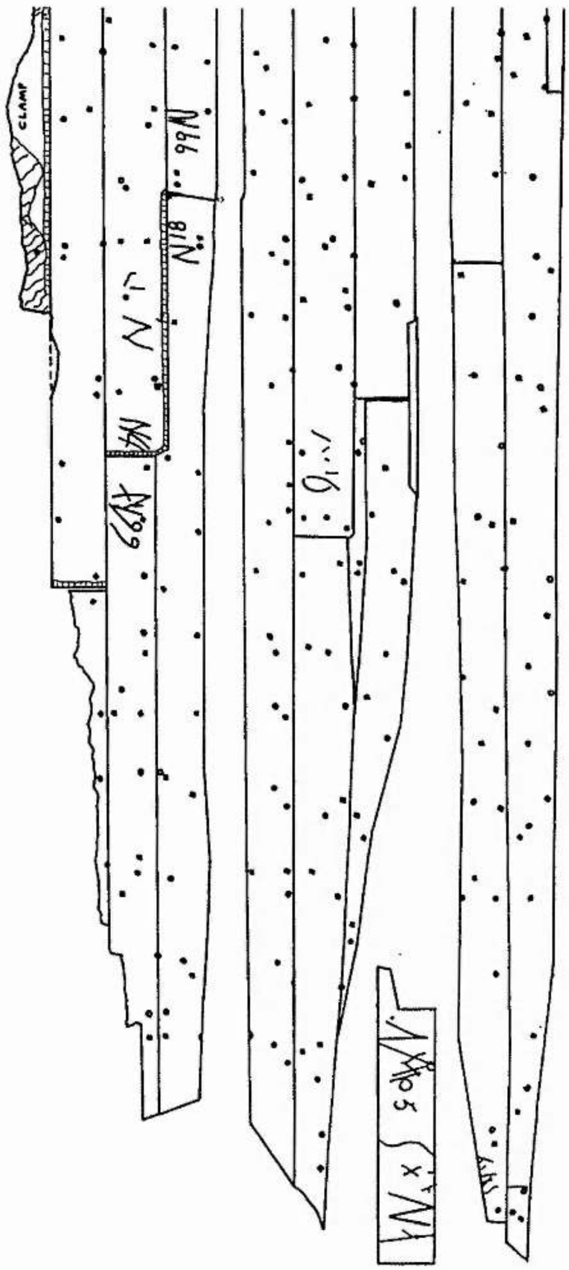


Figure 5.22 44YO88: Ceiling planking, stbd. bow, showing fasteners and graffiti (John D. Broadwater).

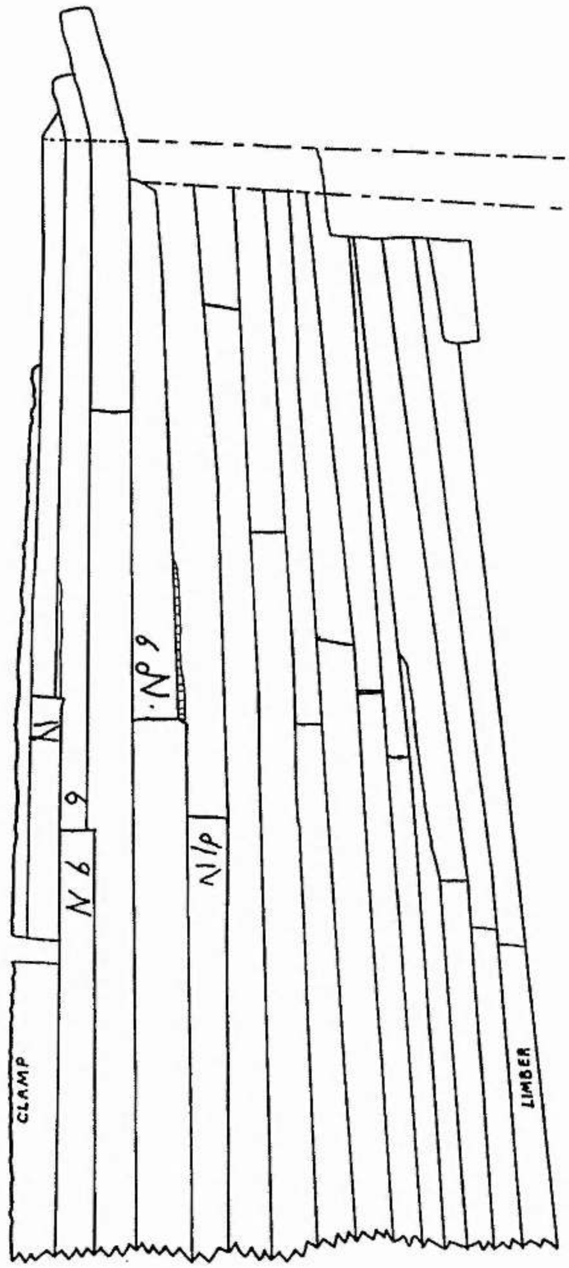


Figure 5.23 44YO88: Ceiling planking, port bow, showing graffiti (John D. Broadwater).

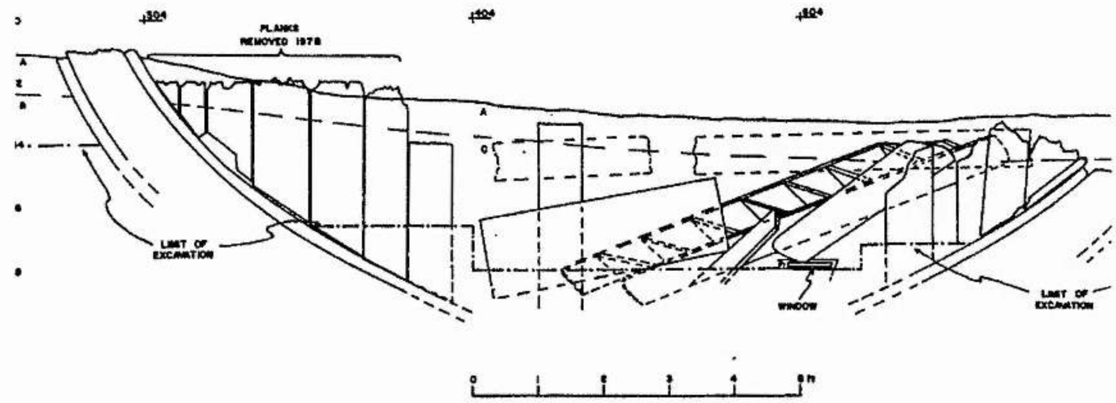


Figure 5.24. 44YO88: aft bulkhead, facing aft (John D. Broadwater, Courtesy Virginia Department of Historic Resources)

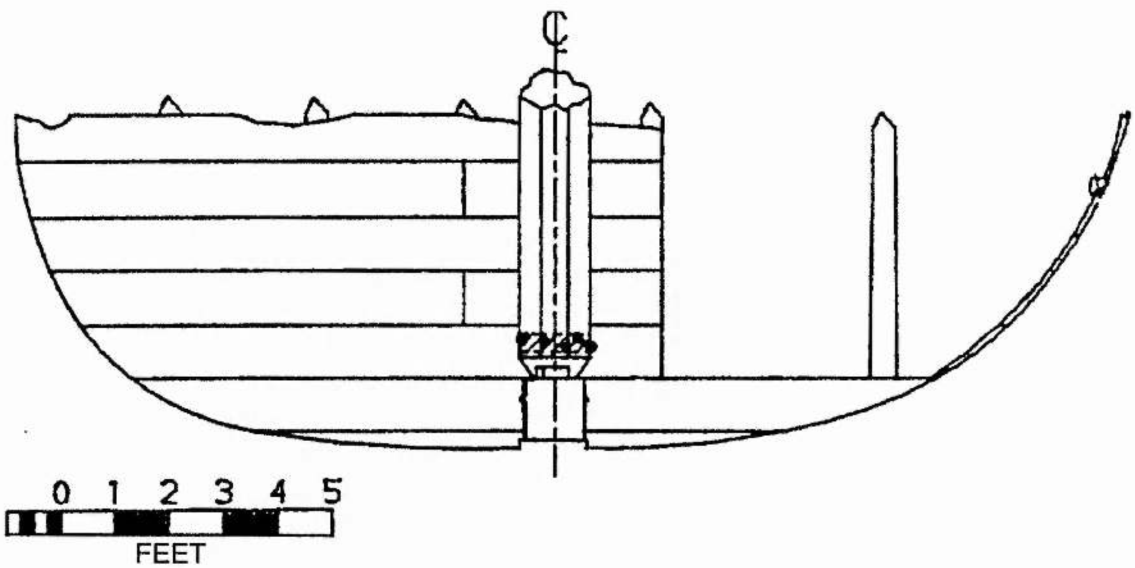


Figure 5.25. 44YO88: forward bulkhead, facing aft (John D. Broadwater, Robert D. Caverly and John W. Morris III, Courtesy Advanced Marine Enterprises, Inc.)

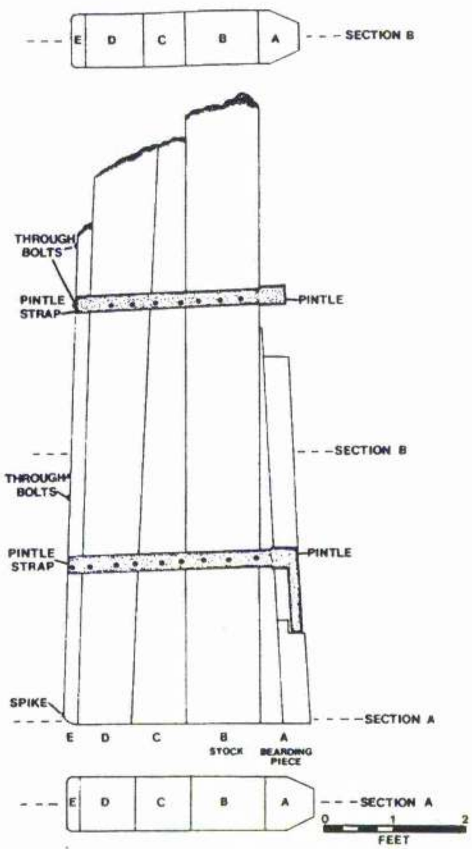


Figure 5.26. 44YO88: rudder showing construction details (John W. Morris III, Courtesy Virginia Department of Historic Resources)

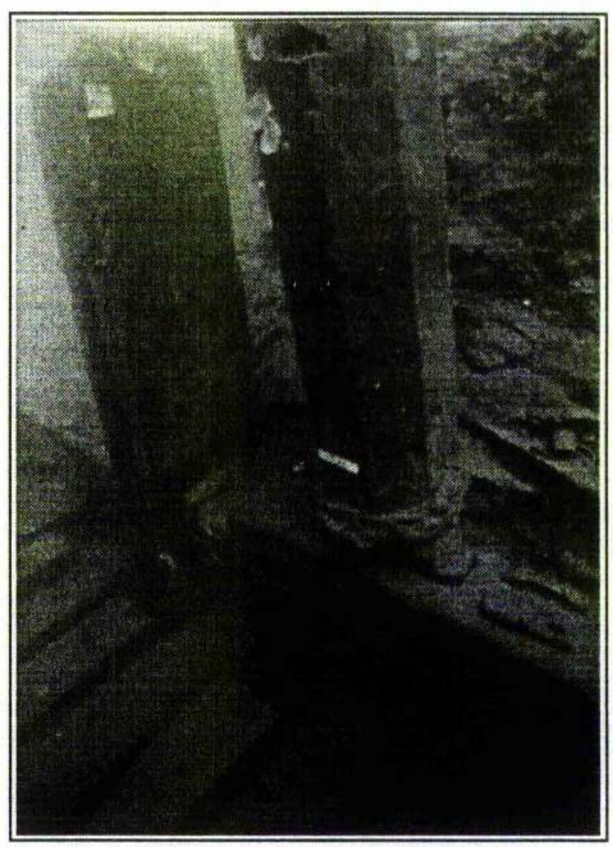


Figure 5.27. Photograph of mainmast and pump box, looking port and aft (John D. Broadwater, Courtesy Virginia Department of Historic Resources)

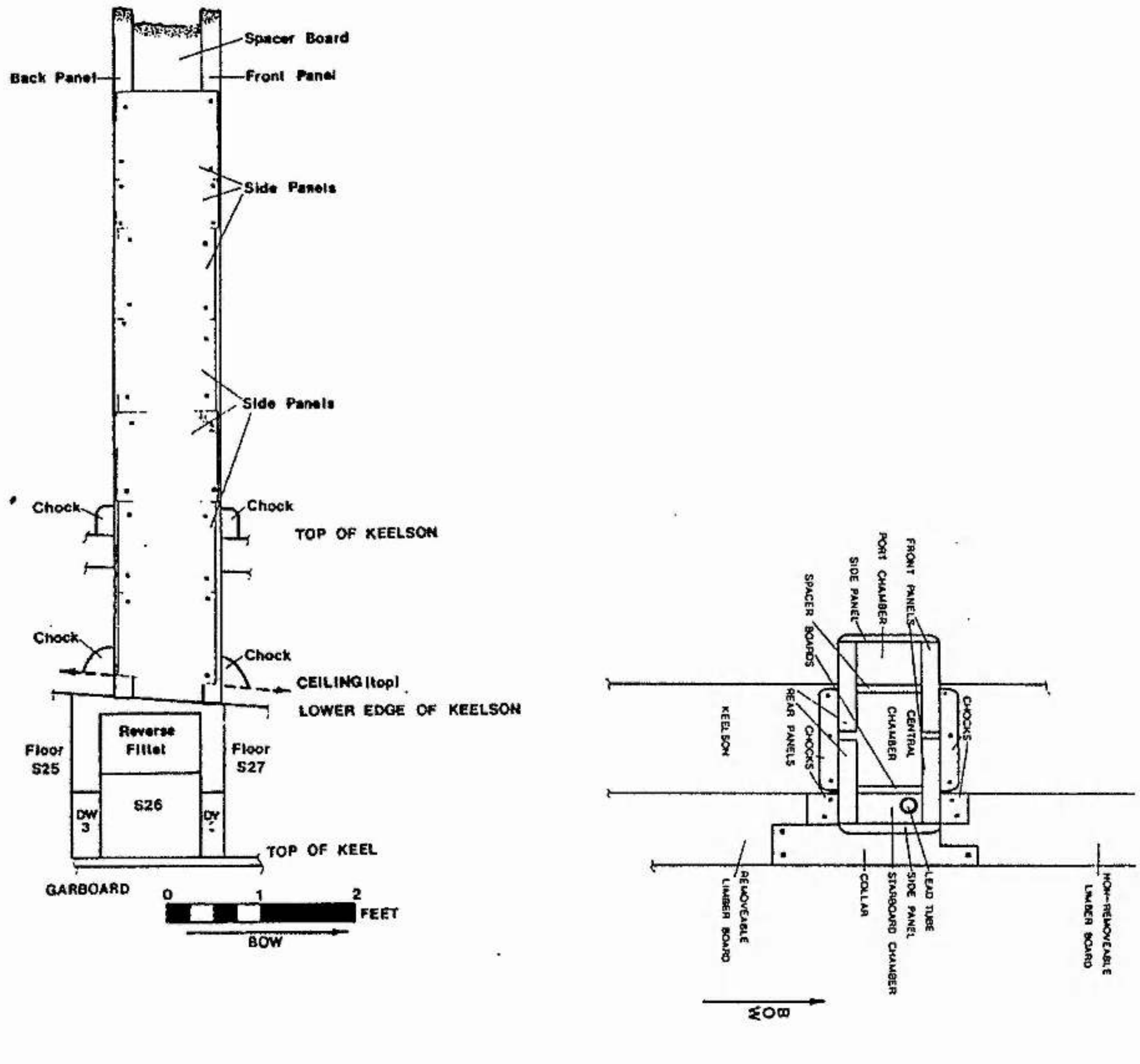


Figure 5.28. The bilge pump. (John W. Morris III, courtesy Virginia Department of Historic Resources)

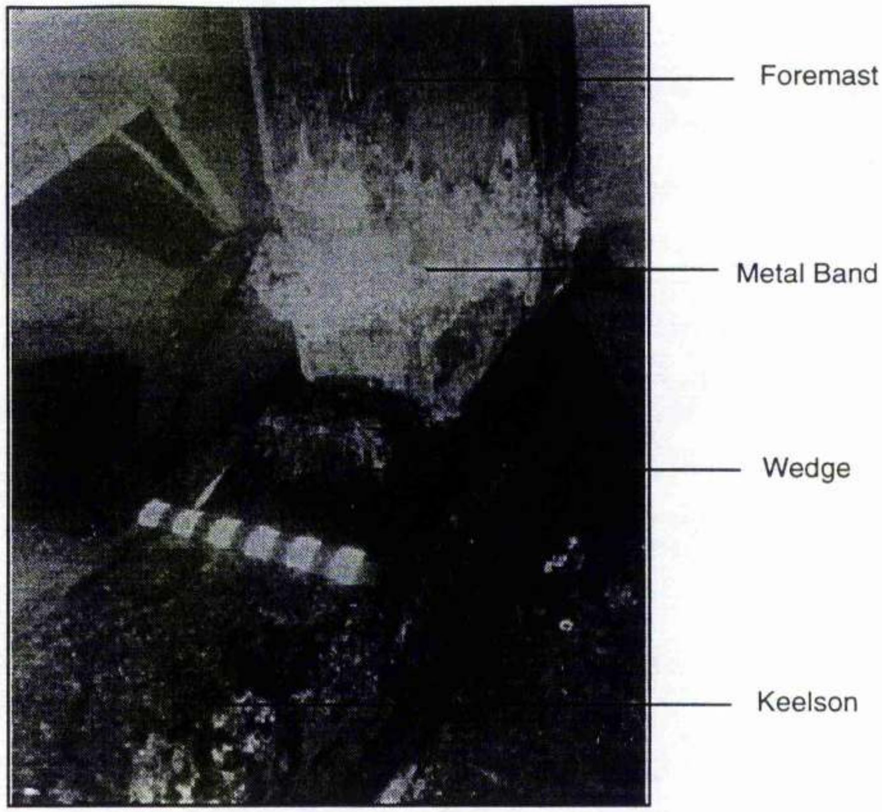


Figure 5.29. 44YO88: photograph of the foremast, facing aft. (John D. Broadwater, courtesy Virginia Department of Historic Resources)

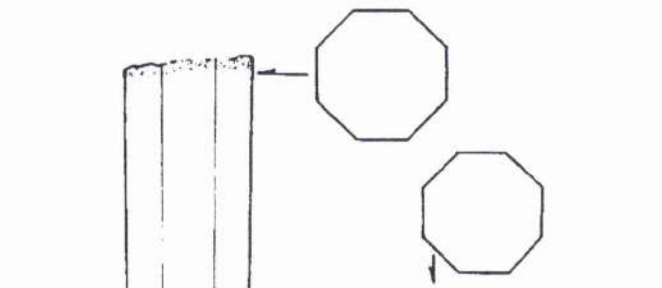


Figure 5.30. 44YO88: the Foremast. (John W. Morris III, courtesy Virginia Department of Historic Resources)

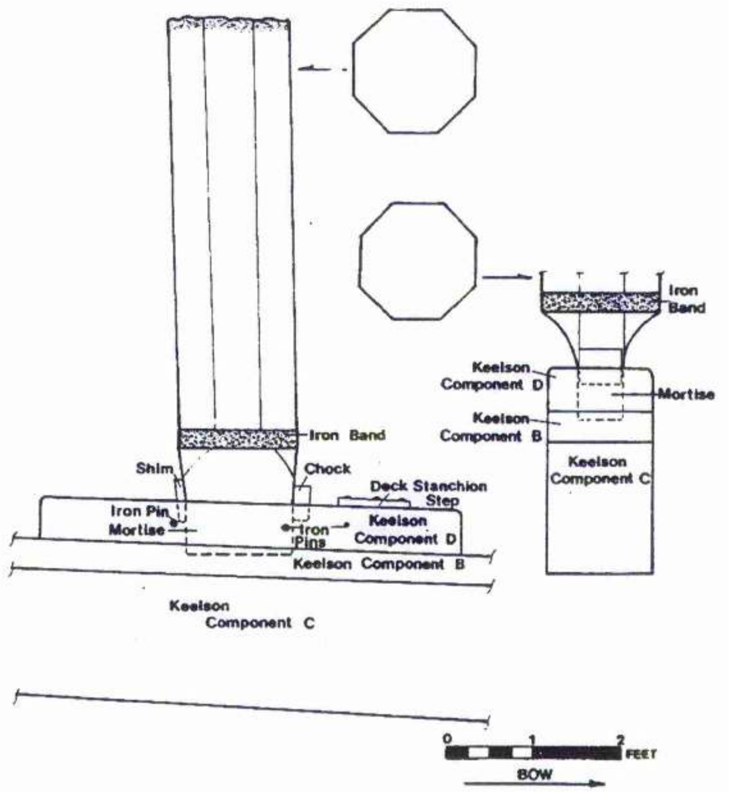


Figure 5.31. 44YO88: the Mainmast, side and section views. (John D. Broadwater, courtesy Virginia Department of Historic Resources)

Figure 5.32. 44YO88: coin in base of mainmast (John D. Broadwater, courtesy Virginia Department of Historic Resources)

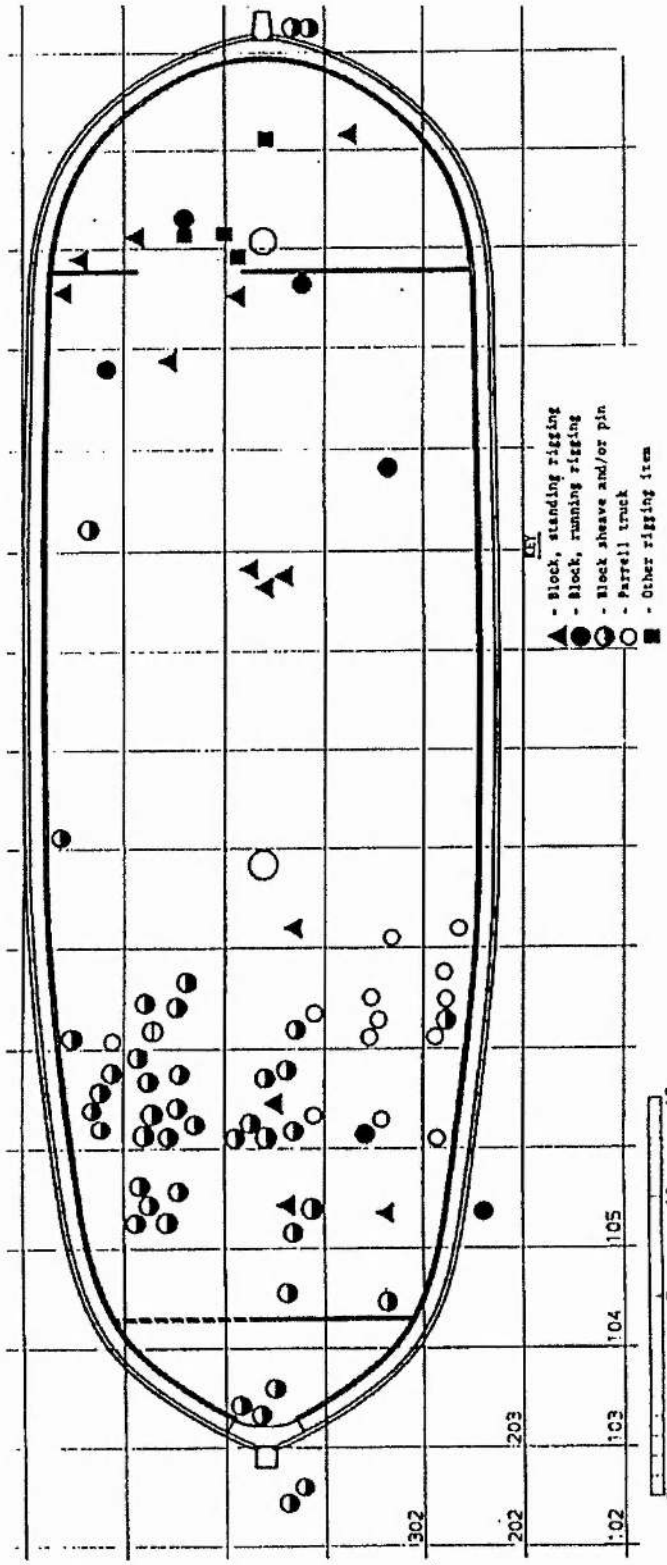


Figure 5.33. 44YO88: Distribution of standing and running rigging items. (John D. Broadwater)

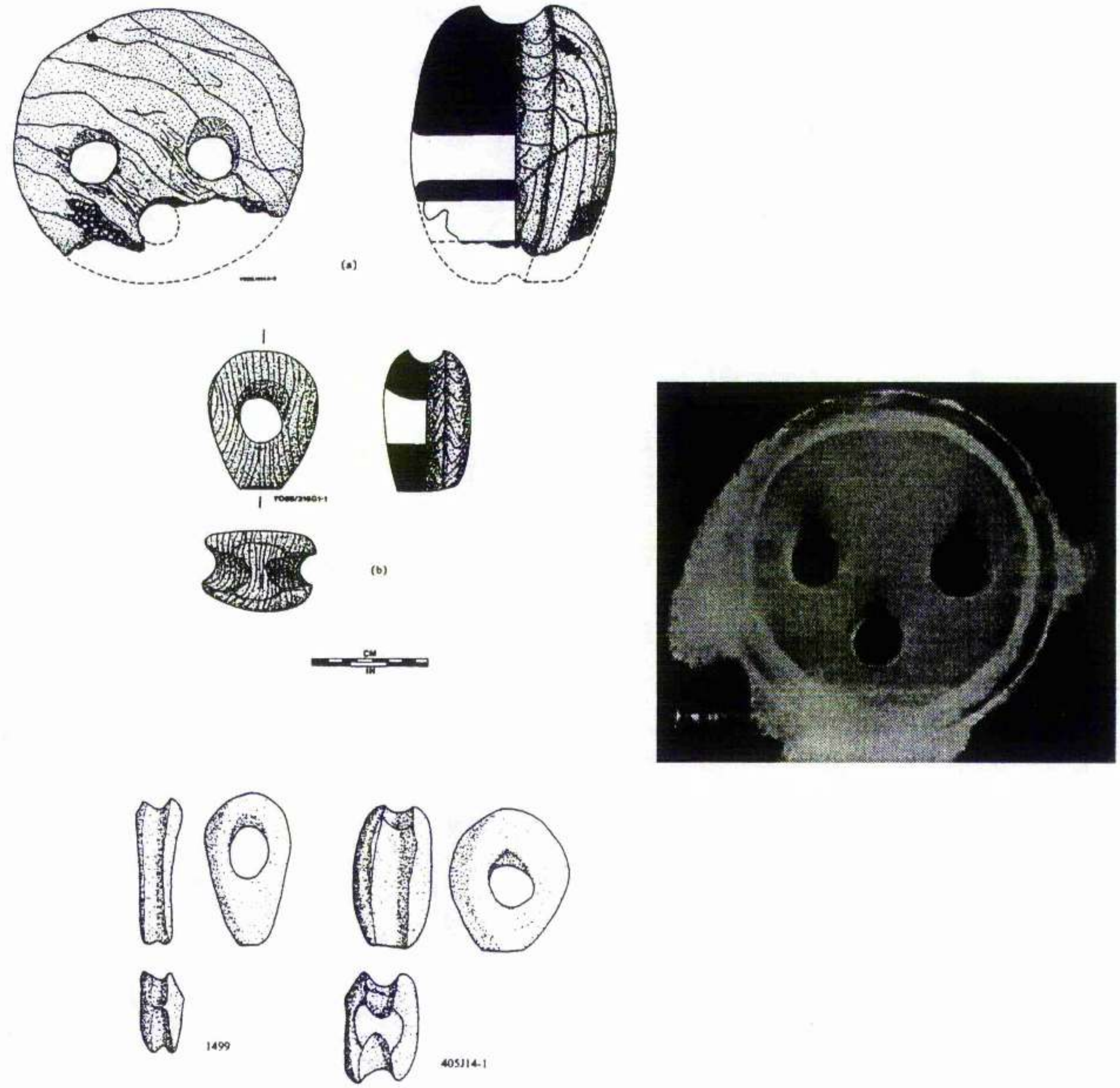


Figure 5.34. 44YO88: an assortment of standing rigging items. Clockwise from upper left: deadeye, x-ray of deadeye with iron strop, three small wooden thimbles (John D Broadwater)

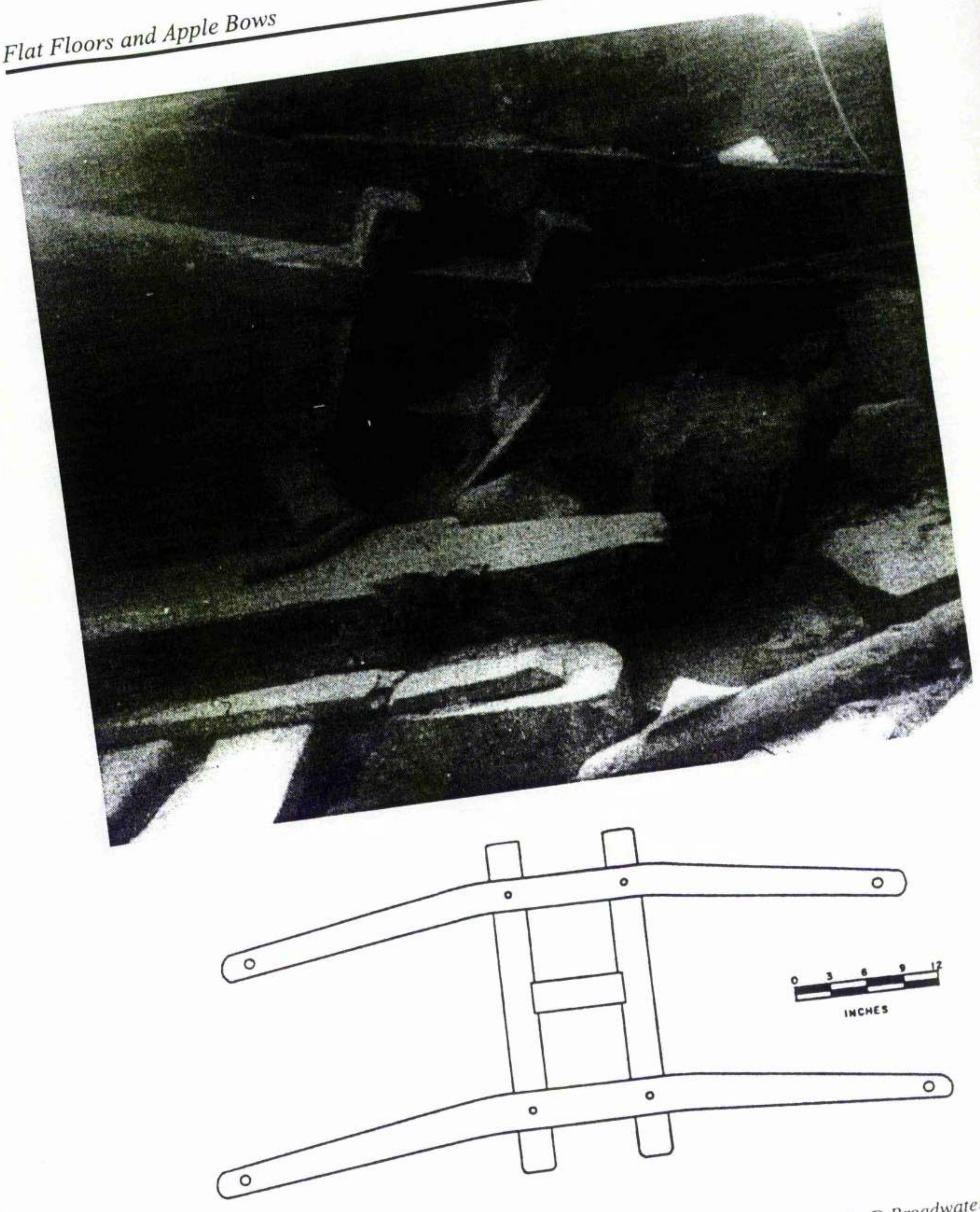


Figure 5.35. 44YO88: the trestletree assembly, above, and illustrated. (John D Broadwater)

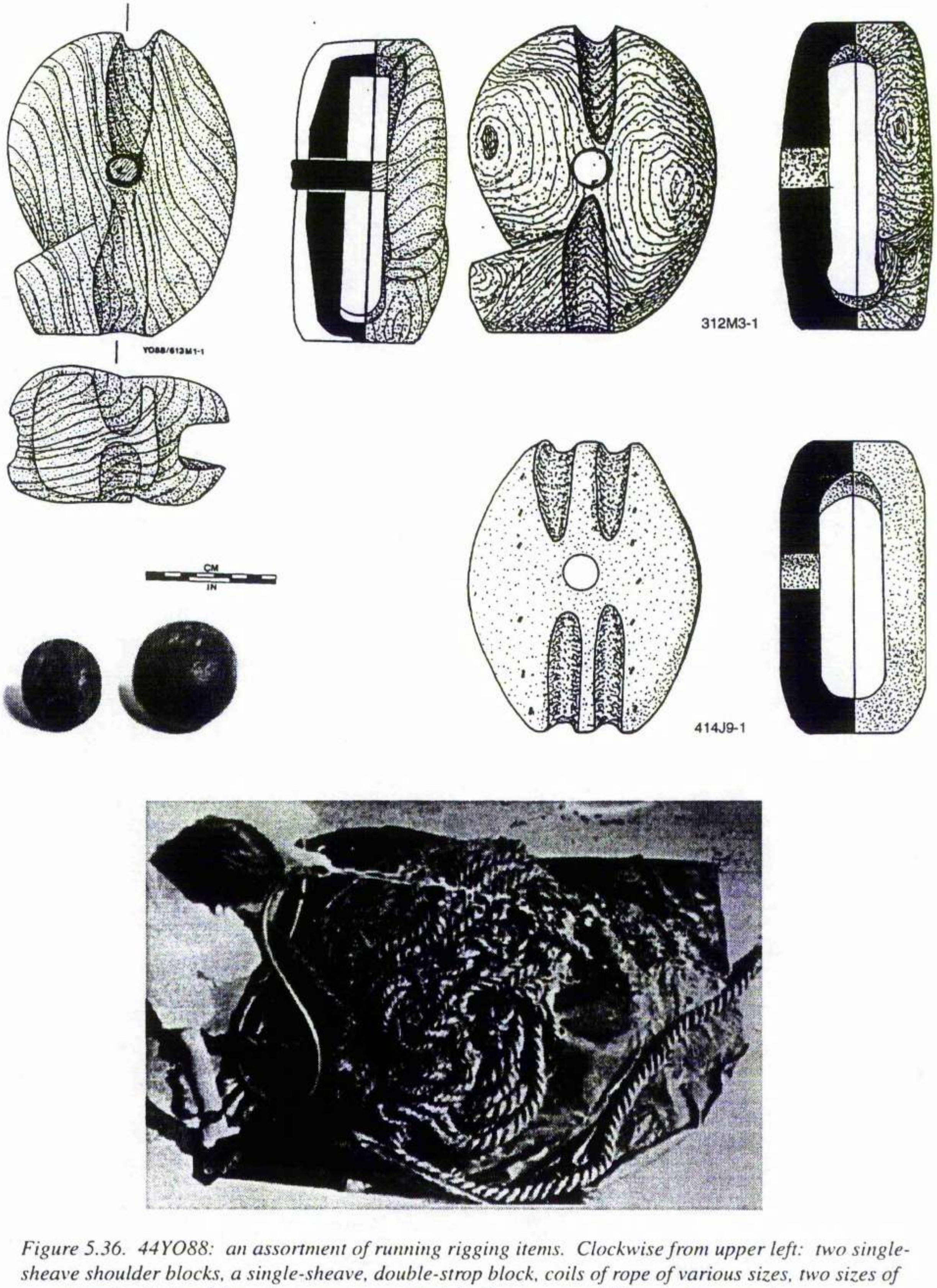


Figure 5.36. 44YO88: an assortment of running rigging items. Clockwise from upper left: two single-sheave shoulder blocks, a single-sheave, double-strop block, coils of rope of various sizes, two sizes of parrel trucks (John D Broadwater, courtesy Virginia Department of Historic Resources)

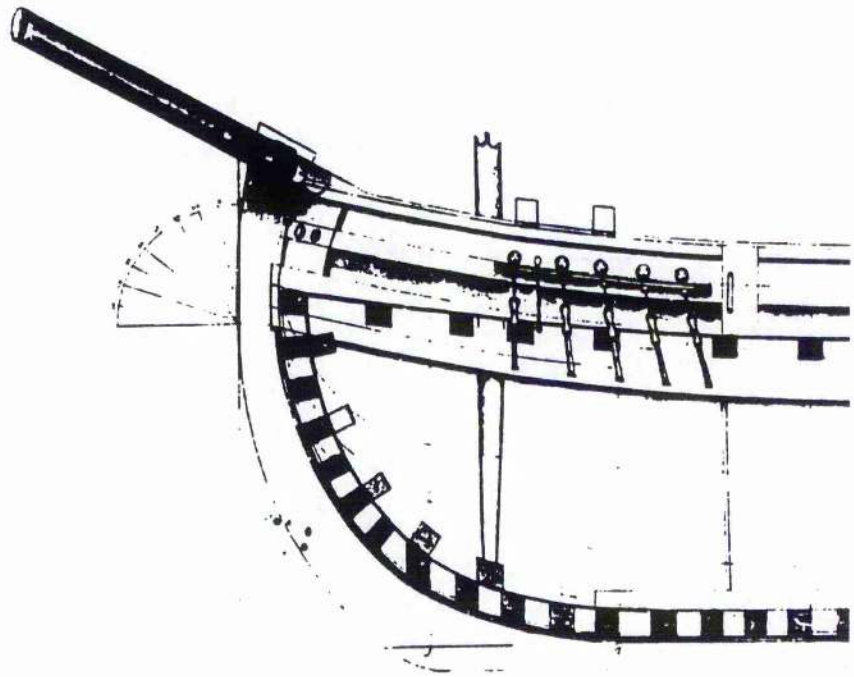


Figure 5.37. Portion of a Dutch draught showing transverse bow chocks similar to those on Yorktown site 44YO88 (Prins Hendrik Maritime Museum:T471)

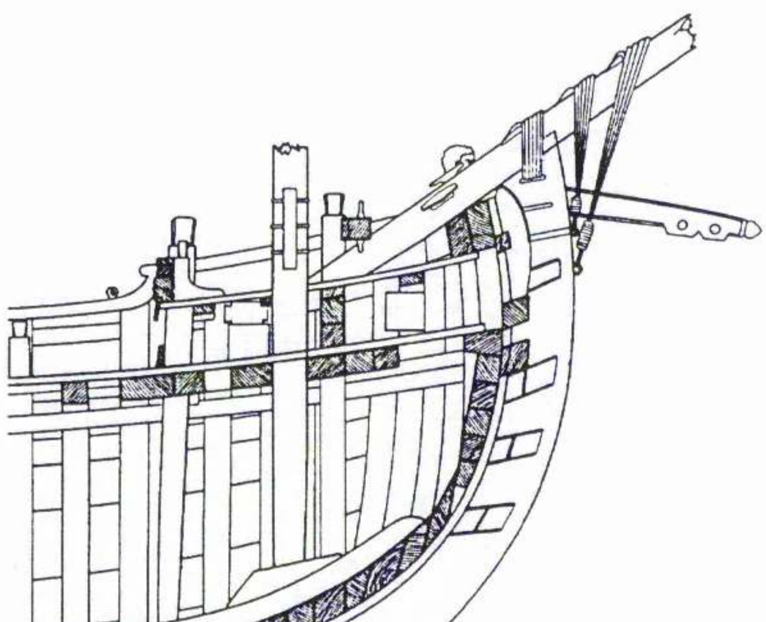


Figure 5.38. Bow construction of a contemporary model thought to be of the Houtpoort, *ca. 1700, showing transverse bow timbers (Prins Hendrik Maritime Museum:M211(18)).*

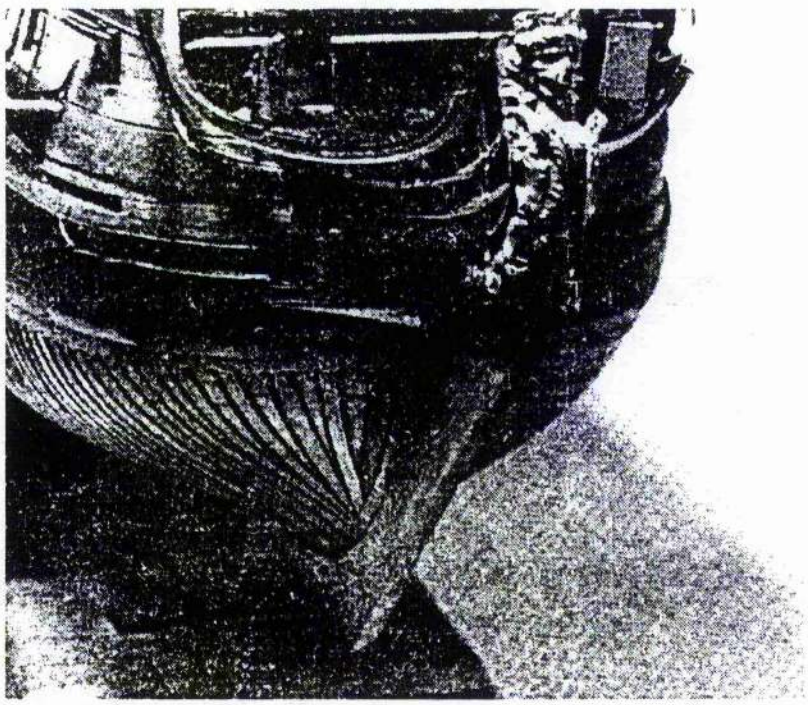


Figure 5.39. A contemporary model of the East Indiaman Somerset, *1738 (NMM:1738-1) clearly showing a bow formed of cant frames (NMM Negative No. B9574)*

Chapter 6

A Reconstruction of the British Collier Brig *Betsy*, 1772

The Yorktown Shipwreck Archaeological Project produced valuable data from one of the largest groups of associated sunken vessels in North America. In the final analysis the most significant accomplishment of the Yorktown Project was the excavation of shipwreck 44YO88, which this study has confirmed to be the British collier brig *Betsy*. The hull was so well preserved that if it could have been raised to the surface and pumped out, it would have easily floated without support. Her unique construction features and exceptional state of preservation offer unparalleled insight into eighteenth-century ship design and construction as well as shipboard interior appointments and life.[1]

The initial analysis of shipwreck 44YO88 clearly demonstrated that she had been a boxy, heavily-built vessel, typical of the English colliers that were so frequently chosen for the Transport Service of the Royal Navy during the eighteenth and nineteenth centuries. Examination of mast placement suggested that YO88 was a brig—a vessel with two masts, setting square sails on both masts and, usually, a fore-and-aft "driver" mainsail. Brigs were very common in the eighteenth century, especially among the colliers of the latter part of the century. A coin was found in each of the two mast steps, but they were too deteriorated to be dated, and no other clues to her original construction date could be found. Nevertheless, the generally good condition of her hull, with very few apparent repairs, suggested that the vessel was relatively new when she sank.

Throughout the project, several questions emerged as most significant: what is the vessel's identity? what caused her to sink? for what trade was she originally built? what specific function did she serve in support of Cornwallis's army? what was her size and appearance? As research progressed, bits of evidence began to form into answers. This chapter attempts to present a complete and detailed description of the *Betsy* and to verify that *Betsy* is a representative example of eighteenth-century English merchant vessels.

Determining the Vessel's Identity

YO88's identity was elusive, since none of the vessels reported sunk at Yorktown matched exactly the size and rig which had been estimated for her. However, diagnostic evidence eventually emerged from several interesting sources, leading to a relatively certain identification.

During excavation, small bits of coal were located throughout the bilges, beneath the ceiling planking, strongly suggesting that coal had been carried as cargo at some time prior to the vessel's last voyage. This evidence fit the original hypothesis that the vessel had been a collier before the war. Analysis of coal residue from the site revealed that it most likely came from a massive coal seam in northern Britain. A specific origin could not be determined, largely because the seam spans Britain and extends even to North America (British Coal, 1991). It is known that most colliers were built in the north of England, near those coal fields (Nef 1932; Syrett 1970).

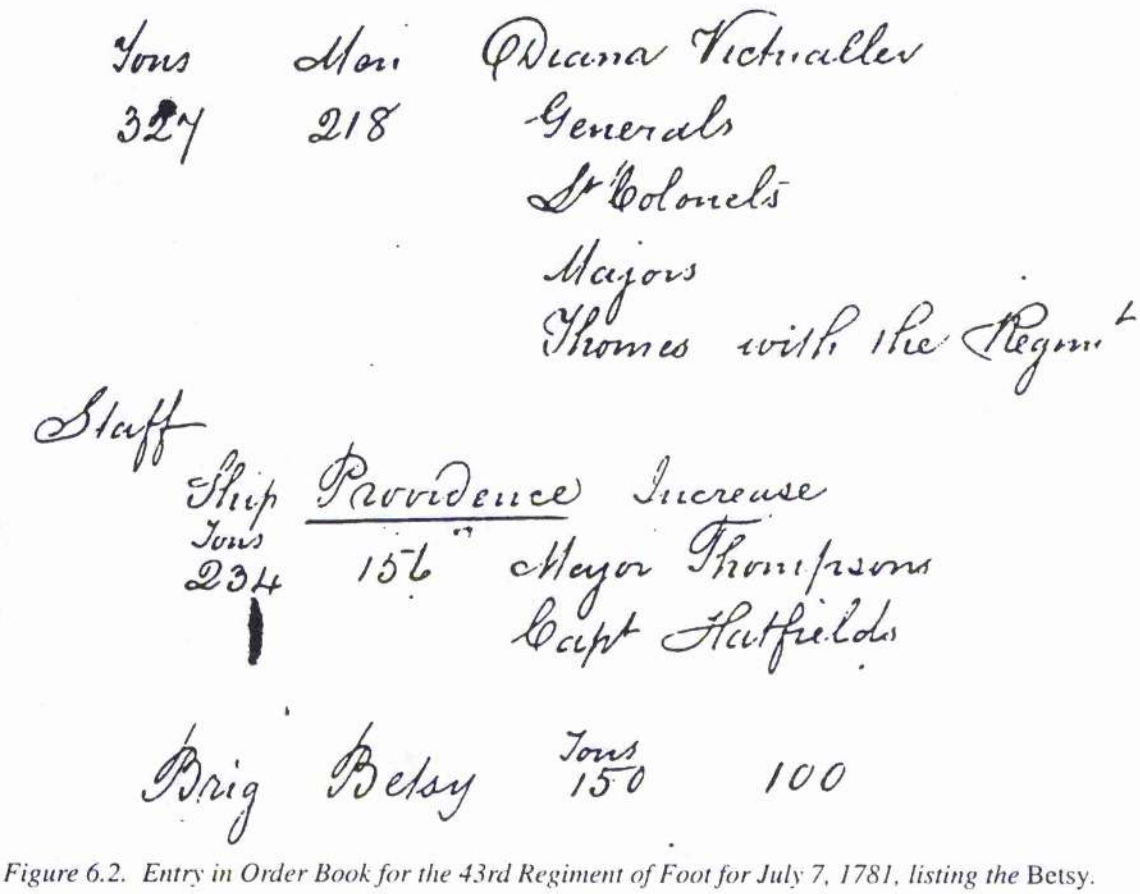
The most significant clues proved to be seven small pewter buttons recovered from the hull. These were uniform buttons from the 43rd Regiment of Foot, a unit that joined Cornwallis at Portsmouth, Virginia in the spring of 1781 (Figure 6.1). Few of the regiment's records are known to survive from this period; however, after several discussions with the author, members of the 43rd Regiment reenactment organization in the United States located the original regimental order book for the summer of 1781.

In the order book was found a crucial clue: The entry for July 7, 1781 recorded that 100 men of the 43rd Regiment were transported from Portsmouth, Virginia to Yorktown on board three vessels: the victualler *Diana*, 327 tons; the ship *Providence Increase*, 234 tons; and the brig *Betsy,* 150 tons (Figure 6.2). Only the *Betsy* was approximately the same size as YO88. Previous research had indicated that a vessel named *Betsy* was known to have been at Yorktown during the siege, but it was listed as a small 30-ton schooner. Nevertheless, the clue was far too important to ignore, so additional research was conducted.

No record of a brig *Betsy* of the appropriate size could be found in British Admiralty records, even among the lists of transports that were indexed by regimental units (unfortunately, *Betsy* is one of the most common ship names). The author has searched a broad range of Admiralty records at the National Maritime Museum, Greenwich, and the Public Record Office, Kew, without locating a single reference to this particular *Betsy*. The most likely explanation is that the vessel was taken into the transport service at one of the outports and, therefore, was not surveyed in a King's Yard at the time. Even though not all the Navy Board records are complete for the period of the American War, it is expected that a reference to the *Betsy* exists somewhere within those documents.

Several lists of the vessels under Lord Cornwallis's command included a *Betsy*, John Younghusband, master, with no tonnage given, and a 30-ton schooner named *Betsey* (Sands 1983:184). At this point, research reverted to a standard reference source: *Lloyd's Register of Shipping,* an insurance register for merchant vessels. *Lloyd's Register* listed a *Betsy*, brig, 180 tons, John Younghusband, master, built in Whitehaven, Cumberland, in 1772. In the listing for 1780 *Betsy*, which had been in the coal trade, was registered as a transport. She was single-decked and sheathed in wood. Those details matched the remains of 44YO88, whose tonnage had been computed at just over 176 tons. Although the vessel was listed by the 43rd Regiment order book at 150 tons, such a mistake or miscalculation would not have been uncommon. There were numerous complaints throughout the

Figure 6.1. Uniform buttons recovered from the Betsy *include buttons from the 43rd Regiment of Foot, the 22nd Regiment of Foot, and the Royal Marines (John D. Broadwater, courtesy Virginia Department of Historic Resources).*



Tons Men Diana Victualler
327 218 Generals
Lt Colonels
Majors
Thomes with the Regmt

Staff
Ship Providence Increase
Tons
234 156 Mayor Thompsons
Capt Hatfields

Brig Betsy Tons 150 100

Figure 6.2. Entry in Order Book for the 43rd Regiment of Foot for July 7, 1781, listing the Betsy.

century about the irregularity of tonnage calculations (Syrett 1970:113). *Betsy* disappears from *Lloyd's Register* in 1782, consistent with a vessel sunk in 1781.

Cultural material from the site also corroborated the identity. Two cask heads and a stave recovered from the lazarette, generally reserved for the captain's stores, bear the inscription "JY" (Figure 6.3). John Younghusband was listed in *Lloyd's* as master and part owner of the *Betsy*. Although not conclusive, these initials offer further confirmation that the vessel is, indeed, the correct *Betsy*.

This *Betsy* was built in 1772 at Whitehaven, a coal port on the northwest coast of England in the county of Cumberland (now Cumbria). With this new information in hand, British Coal reexamined coal samples from the bilge and from the forward hold with the conclusion that the coal "could have come from the Cumberland Coalfield" (British Coal 1991). Although not conclusive, this report strengthened the hypothesis that YO88 is the Whitehaven collier *Betsy*.

As research continued, additional corroborating evidence came from an unexpected source. Samples of a tar-impregnated material were recovered from the outer hull. That

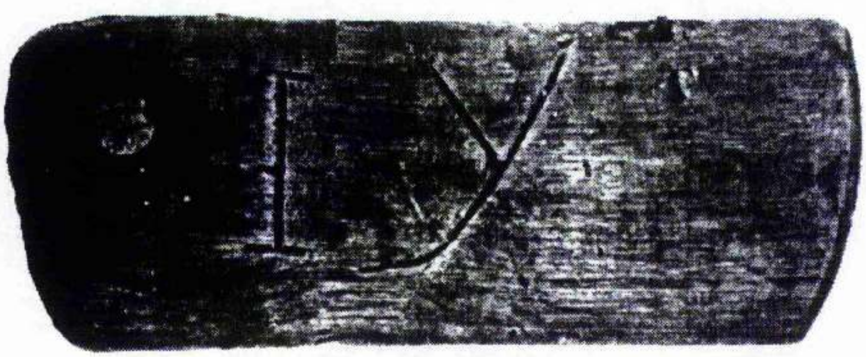


Figure 6.3. Cask head piece bearing the initials "JY" (John D. Broadwater).

material, applied between the outer planking and the wood sheathing, proved to be wool. Analysis in England determined that the most likely source of the wool was Herdwick sheep (Figure 6.4), a breed found exclusively in the relatively-isolated Cumberland area surrounding Whitehaven (Wool Testing Services International, 1991).

This accumulation of evidence leaves little doubt that Yorktown shipwreck 44YO88 is indeed the collier brig *Betsy,* built in Whitehaven, England, in 1772.

The Cause of Sinking

That the *Betsy* was scuttled is without question. The cause of sinking was readily apparent when uncovered during the excavation. Amidships, between starboard frames

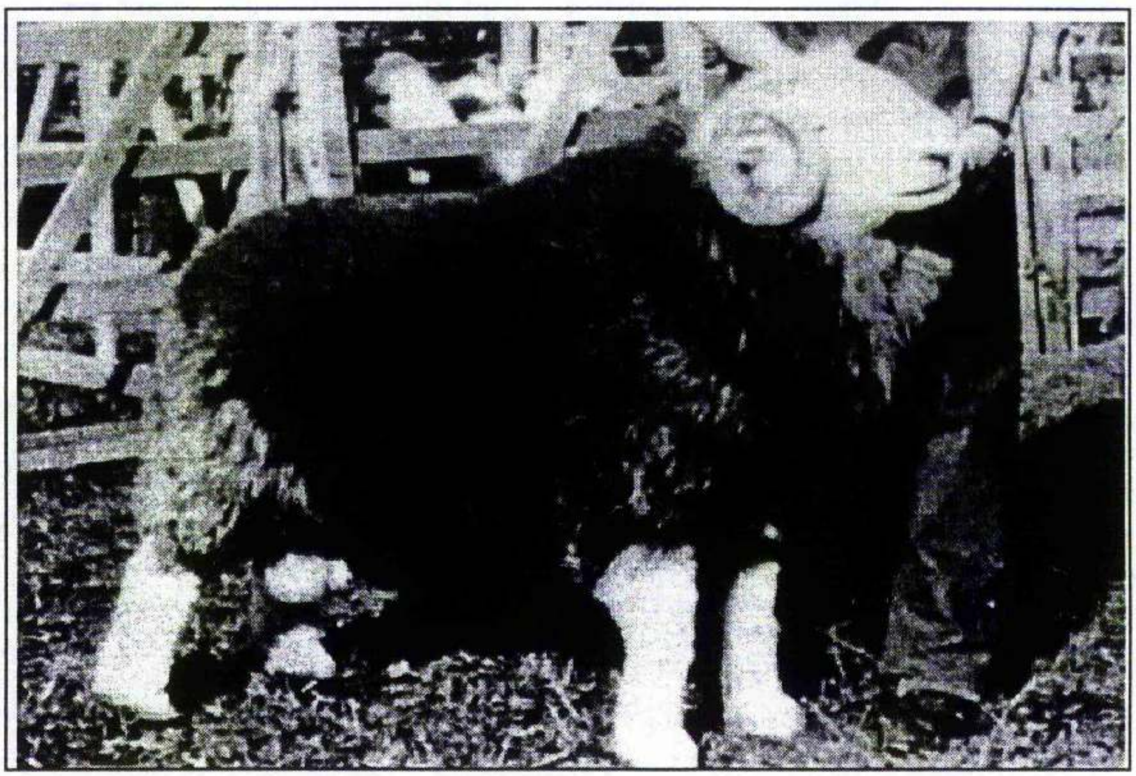


Figure 6.4. A Herdwick ram, Whitehaven (courtesy of Whitehaven Museum).

S23 and S24, a hole penetrated both interior and exterior planking below the waterline. This hole was cut by someone familiar with the ship's construction, since it was positioned exactly between two frames, thus avoiding the necessity of cutting through a thick oak futtock. Somewhat curiously, the segment of ceiling planking had been carefully removed with a chisel, leaving a neat, rectangular opening between two frames, in the strake just below the lower deck clamp. The hole in the outer plank was more ragged and round, measuring approximately six inches in diameter (Figure 6.5).

This method of scuttling the vessel seems unnecessarily complicated and time-consuming compared to boring holes through the hull with a brace and bit or a large auger, as was done on HMS *Fowey* (Master's Log of HMS *Fowey*, October 13, 1781; see Chapter 4). Perhaps a large hole was cut in order to sink the *Betsy* more quickly; perhaps this method was preferred by the person in charge of the scuttling; or, possibly the explanation is simply that the *Betsy* was scuttled using the tools readily available at the time. In any case, the opening of a six-inch hole below the waterline must have produced an impressive stream of water which would have quickly sunk the vessel.

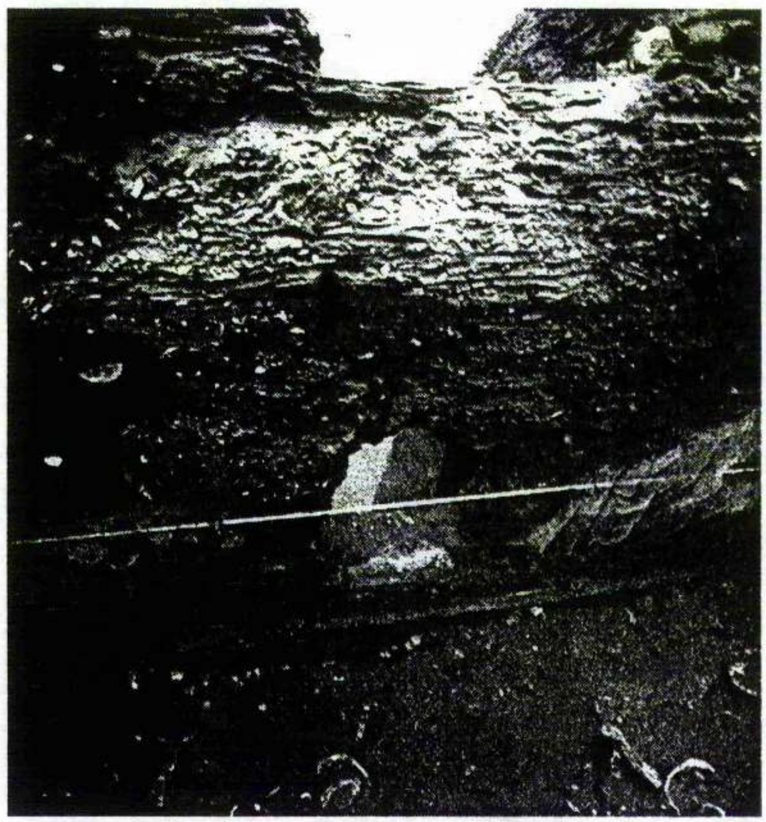


Figure 6.5. Scuttle hole, as seen from outside the hull (John D. Broadwater, courtesy Virginia Department of Historic Resources).

Close examination of the scuttle hole can easily bring to mind an image of the *Betsy*'s carpenter stooping in the dark, cramped confines of the hold, straining to cut a hole through the thick outer planking. With guidance from project archaeologists, an artist captured the act of scuttling in a dramatic painting (Figure 6.6).

Although no documentation has been found to reveal the exact date of *Betsy*'s sinking, her position in line with five other shipwrecks, parallel to the beach, suggests that she was among the first vessels scuttled, on the sixteenth of September, along what was referred to as the "sinking line."

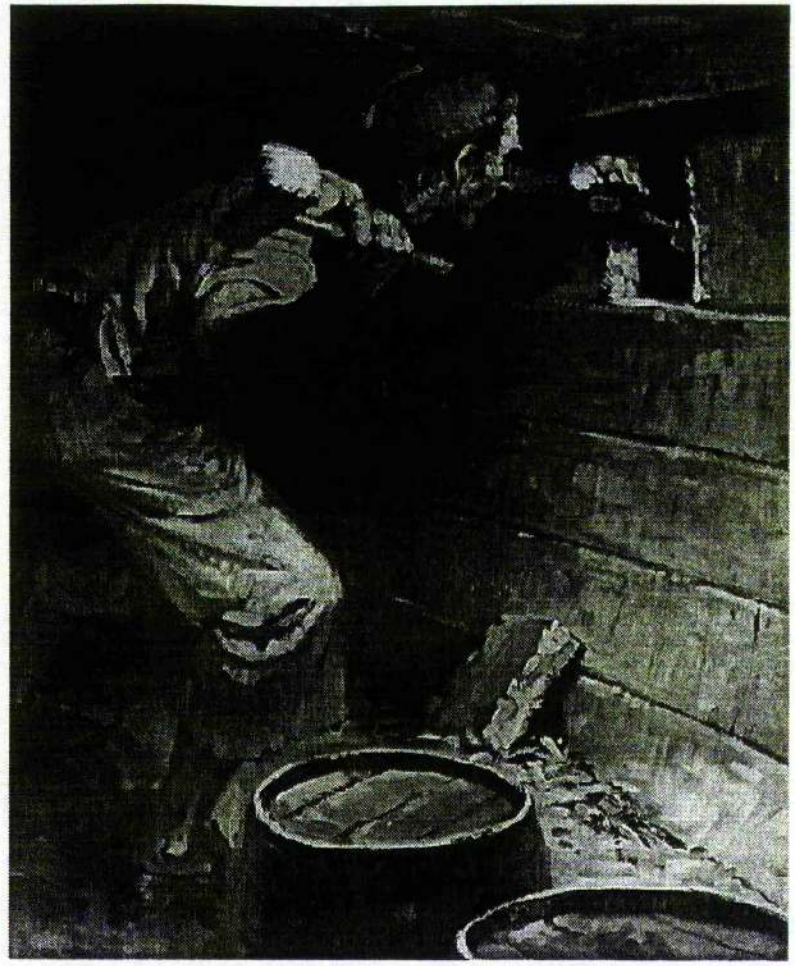


Figure 6.6. Artist's depiction of the scuttling of the Betsy *(Copyright ©1988, Roy Andersen, National Geographic Society)*

Determining the Vessel's Function at Yorktown

The official records of the Royal Navy's Navy Board state that *Betsy* was employed as a victualler, that is, a transport that normally carried food supplies. Designation as a victualler would have been appropriate for *Betsy* in light of the Navy Board's policy of rejecting vessels of under 200 tons for the transport service, but often accepting these smaller vessels as victuallers (Syrett 1970:110). The Navy Board maintained minimum standards for condition, tonnage and space between decks for vessels that were to serve as troop transports; those standards were sometimes relaxed later in the war, when suitable vessels became more difficult to acquire. As discussed above, it is known that *Betsy* served as a troop transport in July, 1781 when she carried 100 men from the 43rd Regiment of Foot from Portsmouth to Yorktown. However, this was a short trip that would not have required berthing accommodations or long-term victualling; therefore, the usual rules would not have applied.

Of more interest and significance is evidence that *Betsy*, while at Yorktown, provided an additional and valuable service to the army. Clues to *Betsy*'s special function at Yorktown derived from the contents of her hold. Below decks, in irregular piles, were found dozens of logs, all of locally-available woods and presumably locally collected. These logs, of various diameters and lengths, lay above or directly atop the sand ballast; several showed signs of partially-completed ax or adz work, and many contained saddle notches near their ends. Several were lashed together with rope. The remains of an adz still lay nearby, near the forward bulkhead, next to a partially-worked log and numerous buried wood chips (Figure 6.7). Most of the timbers did not appear to be suitable for shipboard structural repairs, and their partially-worked state was not consistent with firewood.

It is hypothesized that these timbers were being prepared for use as part of Cornwallis's fortifications at Yorktown. The British had used transports in other wartime situations for the fabrication of fortification materials (Syrett 1991:pers.comm). When Cornwallis brought his forces to Yorktown, he set his men to constructing a series of earthworks and star forts in a layered defense. Such fortifications required wooden supports, stakes and floor boards. To produce these structural members, local trees were cut and brought to Yorktown. Because of the presence of enemy troops surrounding the British position, the timber was probably cut upriver from Yorktown by parties sent ashore from boats or small transports. It seems likely that this timber was then taken aboard specific ships in the harbor where it was rendered into the required fortification components. This was one type of direct support for which Cornwallis could still use his supply vessels. The

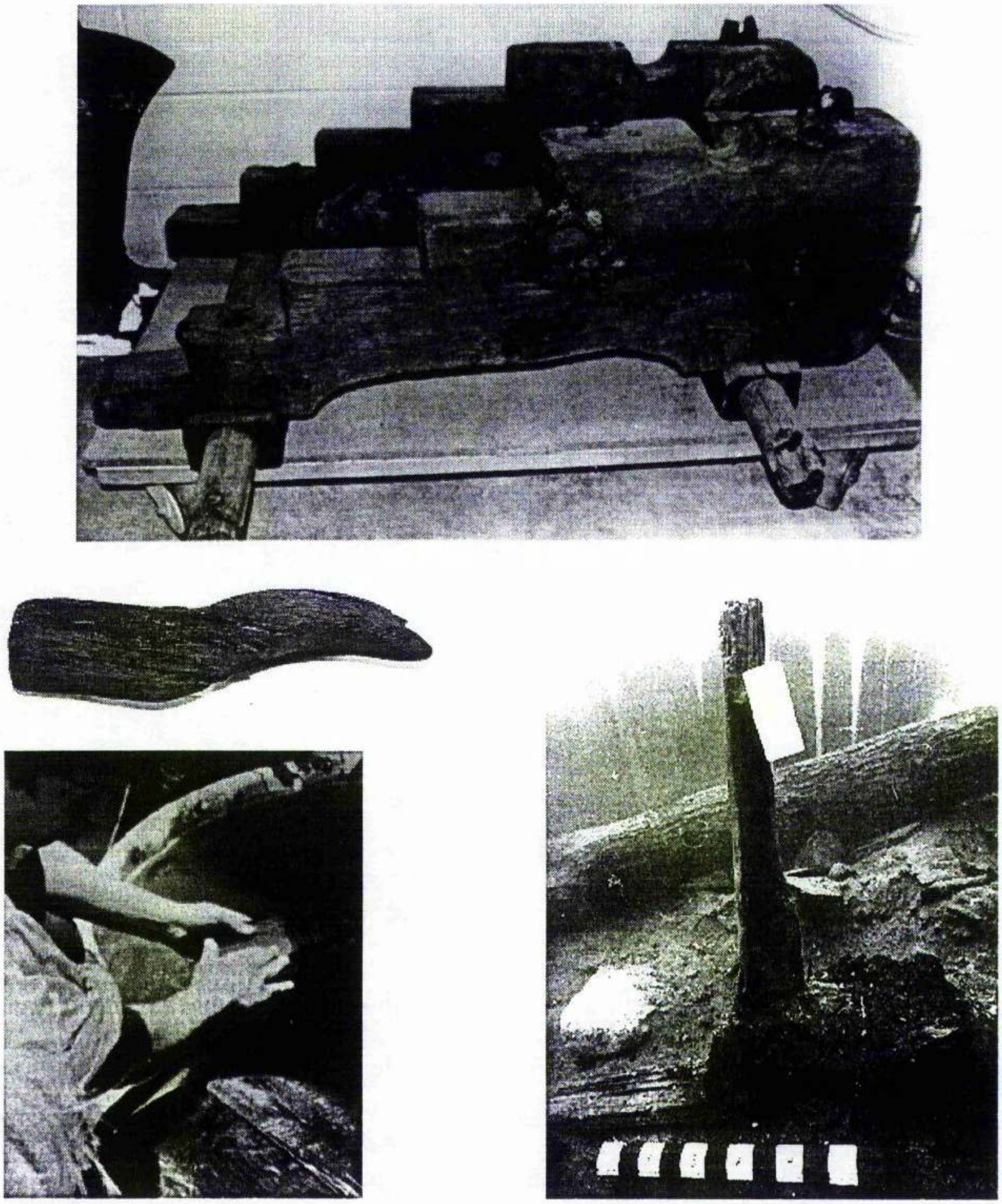


Figure 6.7. Evidence of Betsy*'s use as a "factory ship:" an incomplete cannon carriage (top), a shoe last (center, left), an adz among partially-worked timbers (center, right), and repaired and rebuilt cooperage (all photos by John D. Broadwater).*

timbers could have been safely worked aboard the anchored transports, utilizing them as "floating factories," thus freeing the already-crowded waterfront for ferrying troops and unloading supplies.

In addition to the partially-worked logs, quite a few timbers were found in a completed state, including at least 14 planks (a total of nearly 122 linear feet) that had been shaped, possibly for use as "duck boards." Duck boards would have been placed in the bottoms of trenches, notched to lay over one another, to provide solid footing for the troops in that position (Sands 1991:pers.comm.). However, the "duck boards" aboard *Betsy* were crudely cut, with notches of uneven shape and size, making it impossible for the planks to have been lapped over each other. Nevertheless, it is believed that these worked planks were intended to serve some function in the land fortifications.

Betsy's hold contained additional items which suggested that a variety of repair activities were being undertaken before the ship sank. Barrels had been patched and rebuilt; shoes had been disassembled as if for repairs and a wooden shoe last was found; and an incomplete cannon carriage with one truck (wheel) missing was recovered from the hold (Figure 6.7). Although there is no conclusive verification of the "factory ship" theory, no other viable explanation for the assortment of timbers and tools has been developed. It seems very likely that the crew of the *Betsy* spent the last weeks before the scuttling employed in the fabrication of components for British land fortifications and in the fabrication and repair of other items.

Reconstruction and Interpretation

Based upon extensive historical, archaeological and archival research, it has been possible to develop, with a reasonable degree of confidence, a reconstruction of the *Betsy*'s original appearance and configuration. As described in detail in Chapter 5, the hull remains were carefully and completely recorded, using both electronic and mechanical means. The hull shape was recorded by surveying the curve of the hull at fifteen transverse cross-sections, or stations. All stations were taken to the outer faces of the frames, as is appropriate for developing conventional hull lines. These "station offsets" were fixed in three-dimensional space through reference measurements to the keel and other hull components. Also, all measurements were keyed to the fixed site reference system.

The resulting data were entered into a computer, where a computer-aided design and drafting (CAD) system was used for developing a preliminary set of lines for the preserved hull. The extremely high accuracy and rapid processing capabilities afforded by the CAD system proved to be extremely valuable for analysis as well as for plotting the shape of the surviving hull. Although the computer was utilized in aligning and "smoothing" the lines, such data manipulation was carefully controlled in order to preserve the actual hull shape.

The resulting preliminary lines drawing accurately describes the shape of *Betsy*'s preserved hull remains (Figure 6.8). The drawing is in the form of a standard three-view naval architectural draught (or draft). Analysis of the resulting lines demonstrated that the

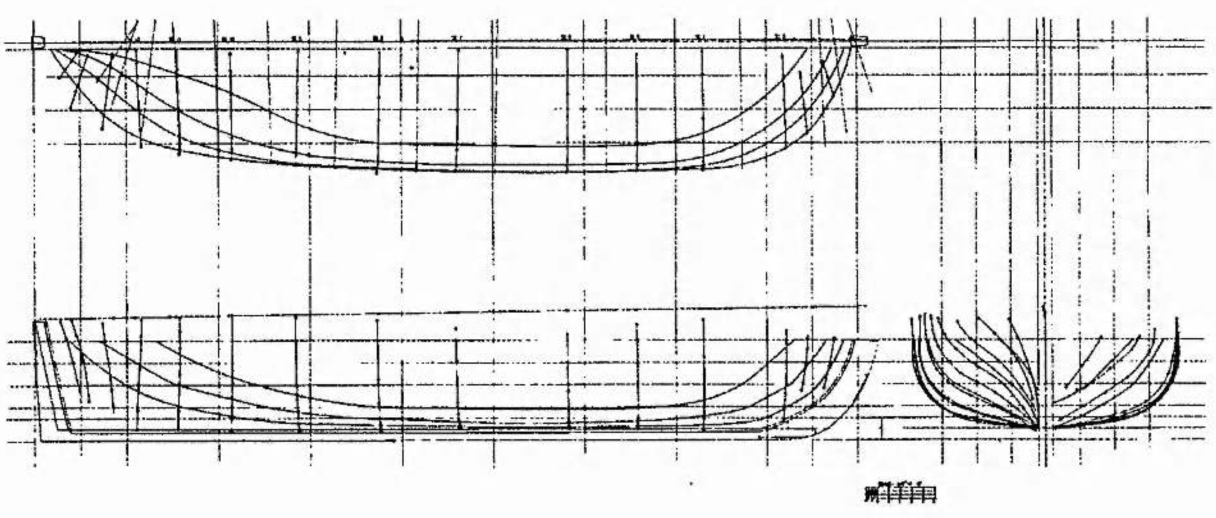


Figure 6.8. Preliminary lines for the preserved hull remains of Yorktown shipwreck 44YO88, the Betsy *(CADD drawing developed by R. D. Caverly, J. D. Broadwater and J. W. Morris III, courtesy of Advanced Marine Enterprises, Inc.).*

hull formed remarkably fair (smooth) curves, indicating a high degree of builder's skill and virtually no hull deformation after more than two centuries on the riverbed. No attempt was made at this stage to reconstruct missing portions of the hull or rigging. All steps leading to this drawing were carefully documented for the benefit of researchers who might wish to verify the process or even to develop their own set of lines. These details were documented in a separate report and large-scale developmental drawings are on file in the project archives.[2]

The next phase of the documentation and interpretation process involved refining and interpreting the lines of the preserved hull remains, leading eventually to a hypothetical reconstruction of the entire vessel by the author.[3]

Although *Betsy*'s lower hull was extraordinarily well preserved, none of the hull above the waterline survived and there was limited evidence of rigging (see Chapter 5). Therefore, an accurate and complete reconstruction was not possible from archaeological evidence alone. Initial inquiries and research, as discussed earlier in this study, indicated that scant information is available on eighteenth-century merchant vessels; even modern scholarly examinations of eighteenth-century ship design and construction concentrate on warships, with few studies on merchant vessels.[4] The author eventually made a total of six research trips to the United Kingdom, where he examined records of the British Admiralty, especially those of the Navy Board; the records of the High Courts of Admiralty; and those of other government agencies, especially those at the Public Record Office, Kew, London, and the National Maritime Museum, Greenwich. He also made two trips to the European continent where he located nautical documents and artifacts that had valuable comparative value. Scores of ships's draughts were examined, and relevant ones were duplicated for further reference. Meetings were held with numerous archaeologists, naval architects, archivists and others who provided an invaluable variety of information and additional sources.

Utilizing all sources of information, a credible reconstruction of the *Betsy* was eventually generated. Based on the reconstruction drawings prepared during this study Malcolm Wilson, a highly respected British model builder, constructed a scale model that combines precise scale reproduction of the surviving hull with physical representations of the reconstructed missing portions. The builder had a particular interest in this model, since his workshop is in Cumbria, only a few miles from where *Betsy* was constructed in 1772.[5] Wilson's model of the *Betsy* must surely be one of the very few full-rigged models based almost entirely on data from an archaeological project.

Building the Betsy

Although eighteenth-century ship construction did not adhere to a rigid, universal convention, this study has confirmed that there were widely-practiced general methods. Furthermore, the physical constraints imposed by hull form and building materials dictated, to a great extent, the sequence of construction. As a result, conventional plank-on-frame shipbuilding has followed the same general pattern since the fifteenth century. Thus, from archival and archaeological data it is possible to present a hypothetical description of *Betsy*'s construction. In this section a brief summary of the presumed sequence of *Betsy*'s construction is described and her emerging appearance is illustrated, using photographs of Wilson's excellent scale model.[6]

As discussed above, the *Betsy* was built in the port of Whitehaven, in County Cumberland, in 1772, for employment in the coal trade. For that service, she was built with a sturdy hull and a flat bottom that would permit her to lie aground at low tide with a full cargo of coal without suffering structural damage or listing too far to either side. She was built in a small shipyard that probably completed only two to four vessels each year. The time of construction may have been a few months or a year, depending on the number of workers and the amount of construction and repair work to which the yard was committed.

The hull form may have been based on a popular regional type or could represent the ideas of a particular shipwright. Likewise, the details of her construction, some of which are unconventional, could be the result of a single builder's innovations or may be an example of a unique regional vessel type that is otherwise unknown today. As discussed in the previous chapter, some of the unique features, especially the transverse bow and stern timbers, may have been adapted from Dutch vessels. The basic hull form was probably preserved and perpetuated by some type of scale model, such as a block model or a skeletal model (bracket or "hawksnest" model), from which the shipwright laid out each new hull.

Once the size and general characteristics of the vessel had been determined, either by contract or by the shipwright, himself, the model would have been used as the basis for transferring the hull lines to full scale on a "lofting" floor. From the model and lofted lines, the keel, stempost and sternpost would have been fashioned; patterns would have been cut for the seven sets of "mold frames" or "master frames" that would establish the shape of the hull. At that point, actual construction would have commenced.

First, her oak keel was carefully set up on blocks, or "stocks," then the oak timbers forming her stempost and sternpost were erected, aligned and fastened onto the keel. Once this "backbone" had been erected, the rabbet would have been cut into the keel and posts. Then, one at a time, the seven mold frames would have been cut, assembled, erected and fastened to the keel (Figure 6.9). These seven mold frames were "compound" frames, that is, each was formed from a floor timber and futtocks, overlapped and fastened together in a single, rigid structure based on the desired form of the ship's body at a given point along the keel. In the *Betsy*'s hull the mold frames were the only ones to be so constructed; as discussed below, the remaining frames were installed in sections after the hull had begun to take shape. (Note that the model builder, adhering strictly to the fastening pattern in the archaeological drawings, was led naturally to follow this same sequence of construction; also, see Chapter 5 for additional details on *Betsy*'s hull construction.)

Frame pair S36/S37 was undoubtedly the midshps bend, or master couple, and this compound frame was probably the first to be erected. This frame is not a "conventional" midships bend, since it has only one first futtock and differs from the others only in having a single bolt joining together its floor and first futtock. That bolt, considered with the position of frame pair S36/S37, strongly suggests that it is the midships bend. The floors were probably crossed first, then aligned, bolted to the keel and shored to hold them in place; then the pre-assembled mold frames, beginning with the first futtocks, would have been erected on their respective floors.

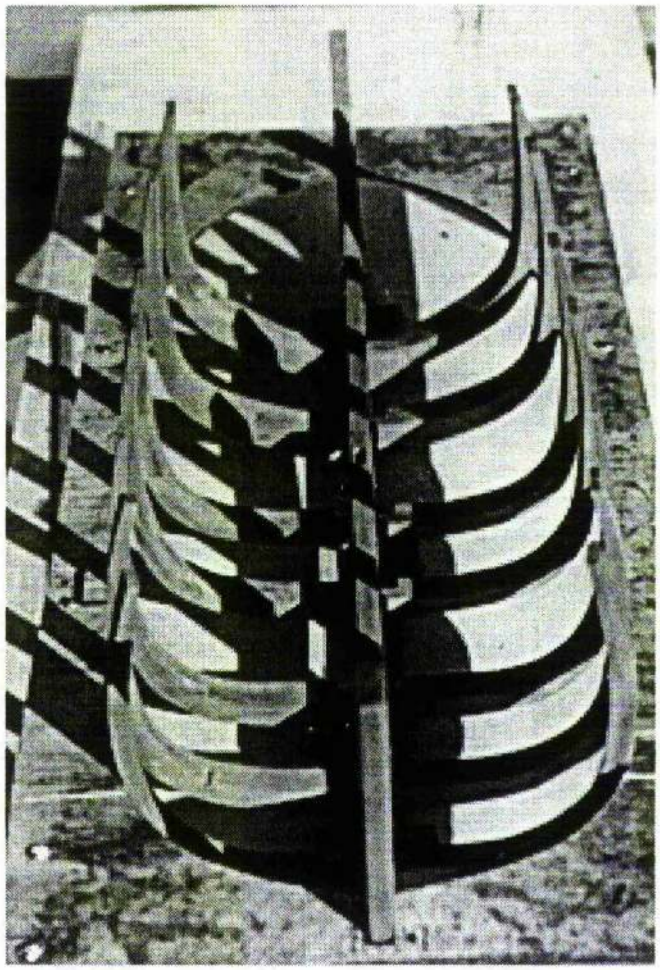


Figure 6.9. The model of the Betsy *under construction, shown after her stem and stern posts had been raised on the keel and the seven mould frames erected (courtesy of Malcolm Wilson).*

Once the complete mold frames were securely aligned, fastened in place, and braced, long wooden battens, called ribbands, would have been fitted along the hull and fastened to the outer frame faces, parallel with the keel, to help hold the frames stationary and to establish the hull form. The remaining futtocks that filled the bow, stern and spaces between the mold frames were not fastened together to form compound frames. In fact, the first futtocks were set off from the keel by approximately one foot (Figures 5.2 and 6.9), making it impossible for those futtocks to have been installed until the hull was partially planked, in order for the planking to provide a surface to which the futtocks could be aligned and fastened. Therefore, the ship was begun in the standard frame-first manner, but the intermediate frames would have been added only after the outer hull had been planked at least up to the turn of the bilge. The framing of bow and stern was unique, as discussed in Chapter 5 and below, and was probably formed using the ribbandsas guides.

After the mold frames were erected and bolted to the keel, and the ribbands installed, it is likely that the construction sequence proceeded as follows. A unique series of horizontal "chock" timbers (termed "apron chocks" at the bow and "transom chocks" at the stern) were aligned and bolted directly to the inside of the posts, forming wide, solid baulks of wood that provided strength and a solid surface to which the planking could be attached. Then the garboard strake was fastened to the rabbet of the keel and the outer planking was added up to the heads of the floor timbers. The *Betsy* was a "double-ender," that is, the wale strakes extended to both the stem and stern posts where they fastened directly to the rabbet and to the transverse chocks. The main wales may have been installed at this point, to establish the sheer and lend strength (Figure 6.10).

After this, the floors and first futtocks of the intermediate frames were added, then the planking was continued up to the heads of these futtocks. The planking and futtock

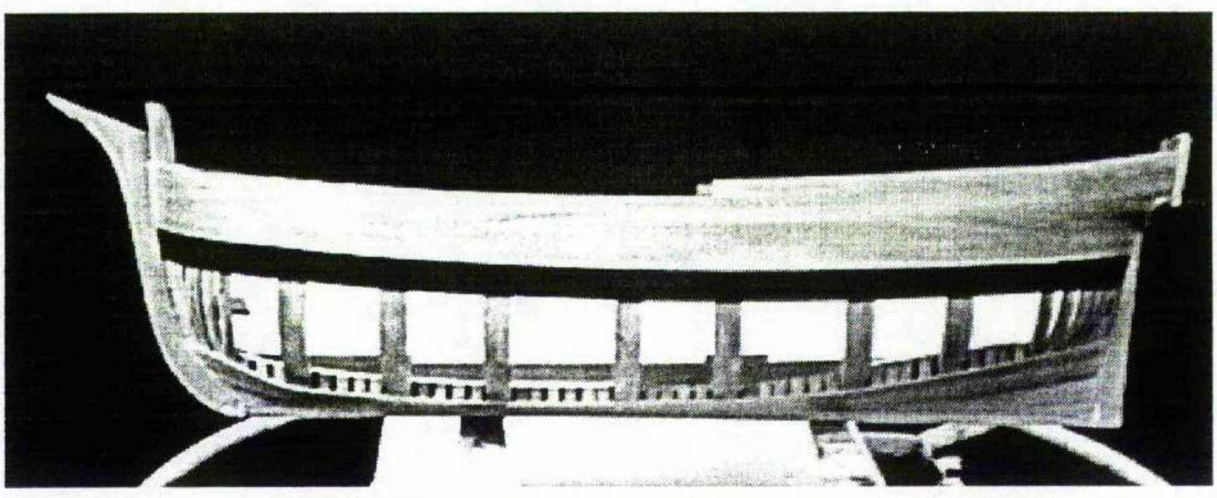


Figure 6.10. The Betsy *model under construction, shown in a cutaway profile after her main wales (dark band) and most of the outer planking had been added (courtesy of Malcolm Wilson).*

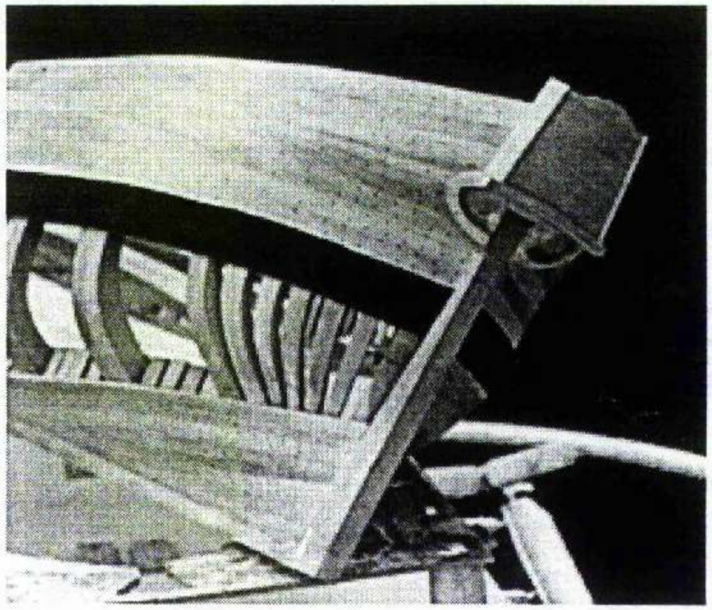


Figure 6.11. The Betsy *model under construction, showing the "pink" stern and cant frames, with the wales and planking terminating at the stern post (courtesy of Malcolm Wilson).*

installation continued in this fashion until the top timbers had been installed and the hull had been planked up to the gunwale. Once all floor timbers were in place, the keelson would have been fitted over the floors and fastened with iron through-bolts, thus securing the keel, frames and keelson into a strong, rigid structure. Along with the installation of the keelson, the breast hooks and crutches may have been installed. The cant timbers of the bow and stern may have been installed after the planking had reached the level of the lower wale.

At this point the wales, the thick planks running the full length of the vessel just above the load waterline (the dark bands visible in Figures 6.10 and 6.11), were probably added to further strengthen the hull. Inside the hull the deck clamps, thick longitudinal planks on which the deck beams were supported, would have been installed at the levels of the lower and upper decks. The deck beams would have been fitted and deck lodging knees would have been added for further strength, as would crutches and deadwood (Figure 6.12).

The *Betsy* was built with a "pink" stern, in which the wales and planking bend around the stern and terminate at the sternpost, forming a very narrow stern. The termination of the wales and planking, as well as the shape of the small transom above the wale, can be clearly seen in Figure 6.11.[7] The exact shape of the counter and stern selected for the model is conjectural, but is typical of small brigs of the period. The counter might have been slightly broader and more rounded, and it is possible that the upper stern was flared to a round tuck configuration to provide additional space in the after cabin; the stern counter may have contained several small windows. In this interpretation presented here, there were no stern windows but, rather, a small window known as a "quarter badge" was installed on either side of the after cabin.

Once the framing and planking was completed, ceiling (inner planking) and lower deck planks would have been added. For a small vessel, particularly a collier, the lower deck would have been planked only near the ends, to provide platforms for ship's stores and cables; the central beams would have remained unplanked for easy stowage of cargo. The upper deck would then have been planked, and the chains, chain-plates and lower deadeyes would have been fitted. Planking and decking would have been caulked.

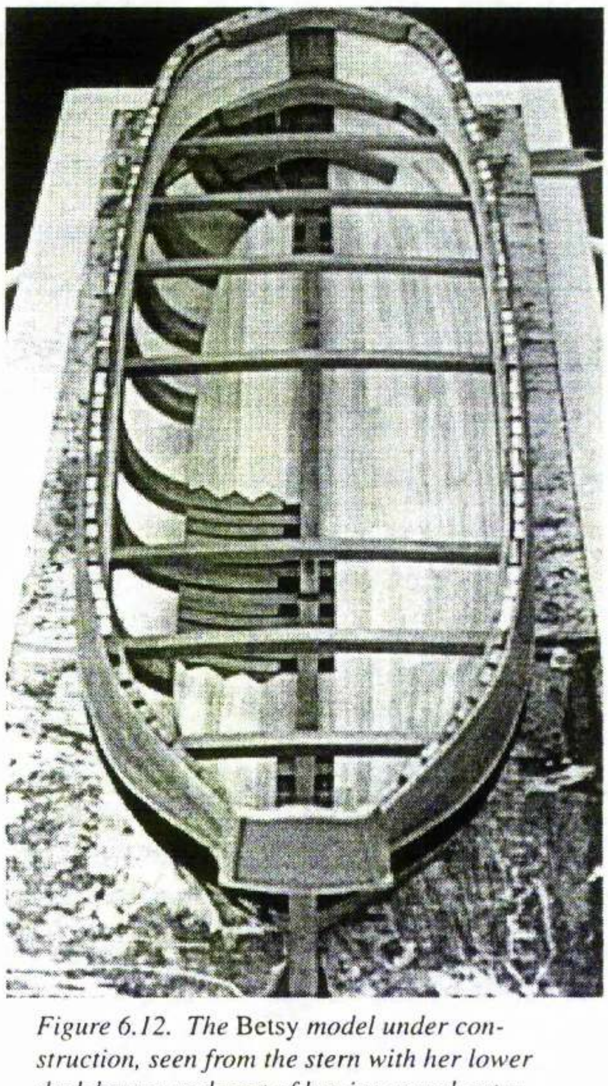


Figure 6.12. The Betsy *model under construction, seen from the stern with her lower deck beams and part of her inner and outer planking added (courtesy of Malcolm Wilson).*

At this stage of construction, the vessel may have been launched, generally by allowing her to slide down her keel support structure and into the water; or she may have been floated off at high tide. She would then have been tied alongside a pier or bulkhead, where a sheer, a type of crane, would have been used to step the lower masts and the bowsprit. Once both lower masts had been aligned, wedged and secured in position with shrouds and stays, the upper mast sections and yards would have been added and all rigging set up. The bowsprit would have been aligned, wedged and gammoned, and the jib-boom installed. Deck furniture (windlass, bitts, pumps, etc.) would have been installed. Additional deck fittings and hardware would have been fitted and carpenters would have added bulkheads, cabins and other interior appointments.

After additional fitting out, painting and other finish work, the *Betsy* would have been ready to be turned over to her owner and placed in service. In *Betsy*'s case, that service was transporting coal from the Whitehaven staithes to Dublin, Ireland.

A Portrait of the Betsy

Betsy was a solidly-built vessel with heavy construction of oak frames and planking (Figures 6.14 and 7.13). Her reconstructed lines (Figure 6.15 and Plate II) demonstrate that she had a broad, flat underbody, full-floors with slight deadrise and rounded chines, and a long, nearly-parallel midbody.[8] Her bluff bows gave way to a full midships section with a relatively fine run aft. She had two masts and a partial lower deck. In carrying capacity she measured 176 $^{32}/_{94}$ tons, burthen. She was of a generic class of bulk carriers often referred to as collier brigs, even if their cargo was not coal.

Her interior arrangements were simple and functional (Figure 6.16). She had a lower deck that was planked only in bow and stern. In the bow was storage space for equipment and provisions; in the stern were cabins and additional storage. At Yorktown, the lower hold contained sand ballast, the surface of which served as a deck for the hold. When she was in service as a collier, her entire hold would have been loaded with coal. She may have made the return trip with some type of bulk cargo or may have carried sand or stone ballast.

Her final appearance must have been similar to the reconstruction shown in Figure 6.17 and Plate III. She had simple, functional lines, with only a knee at the beak to which

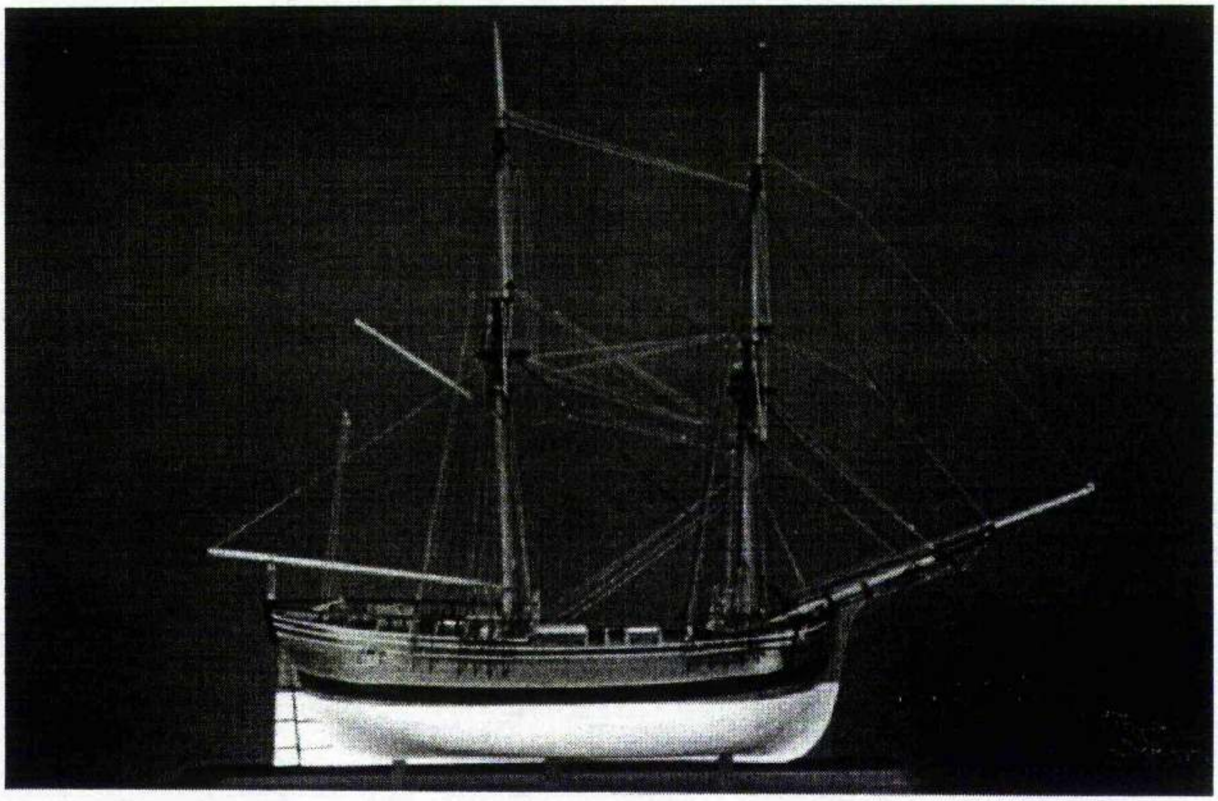


Figure 6.13. Malcolm Wilson's completed model of the Betsy *(courtesy Jamestown-Yorktown Foundation).*

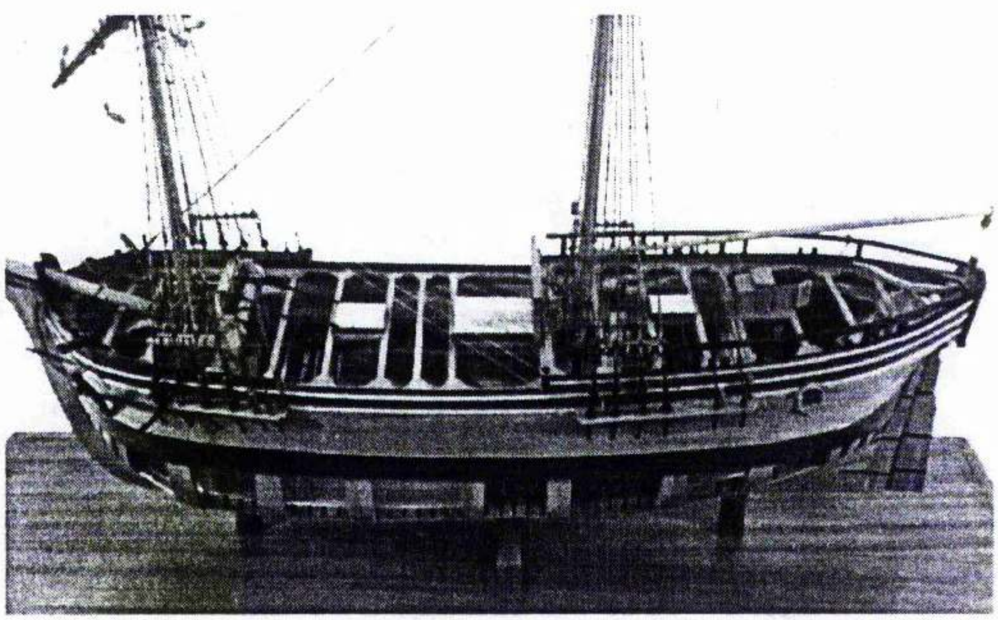


Figure 6.14. Malcolm Wilson's completed model of the Betsy*; part of the port side planking has been intentionally omitted to show interior construction (John D. Broadwater).*

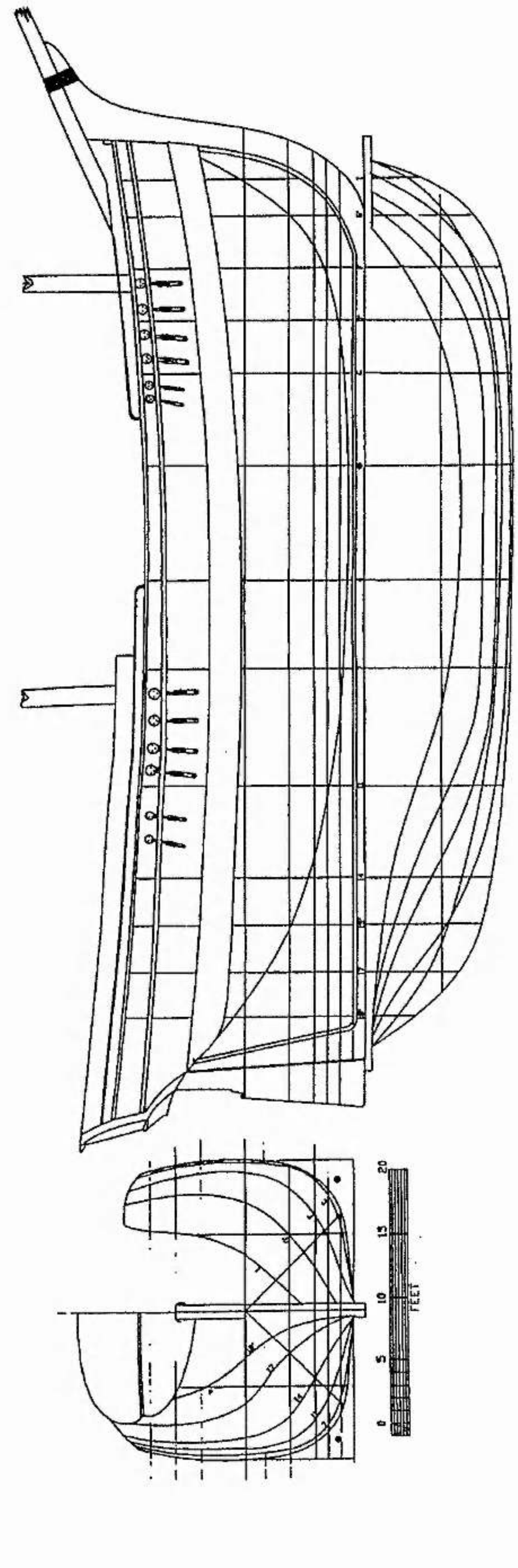


Figure 6.15. Reconstructed lines drawing of the Betsy *(Copyright 1995 John D. Broadwater).*
[See also Plate II]

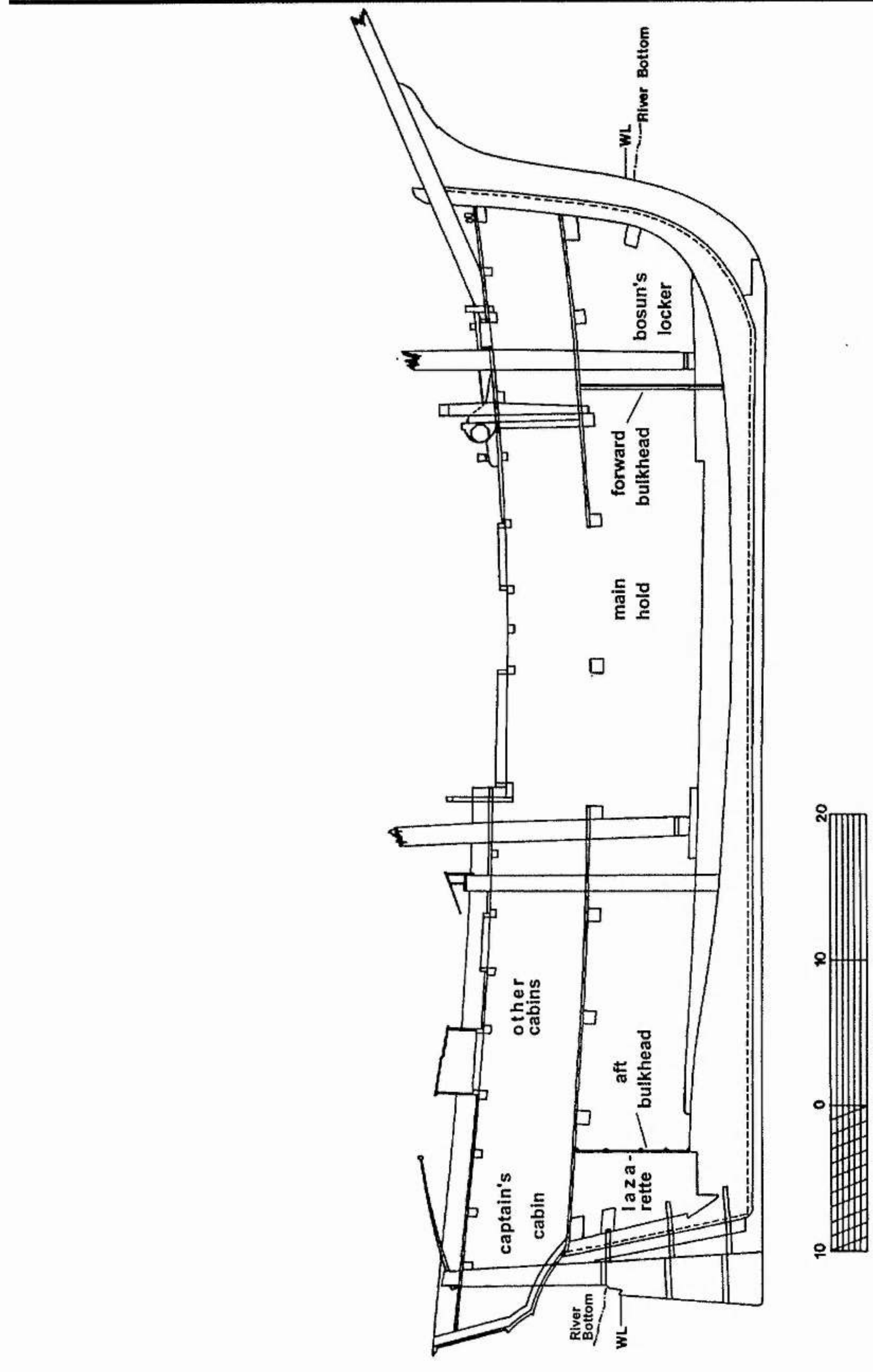


Figure 6.16. Reconstructed interior arrangement of the Betsy *(John D. Broadwater, courtesy Va. Department of Historic Resources).*

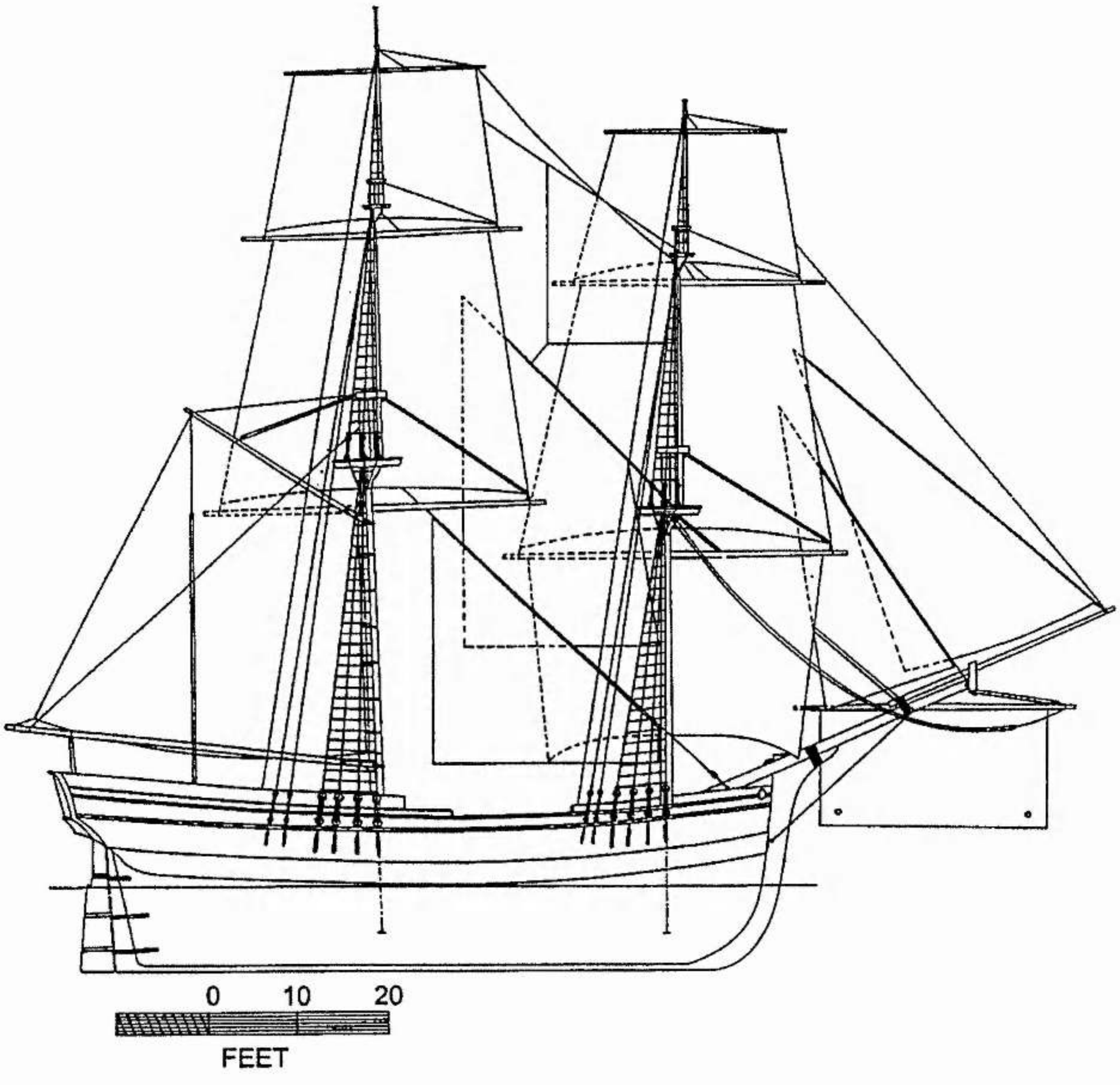


Figure 6.17. Final reconstruction of the Betsy, *showing hull and rigging (John D. Broadwater).*
[See also Plate III]

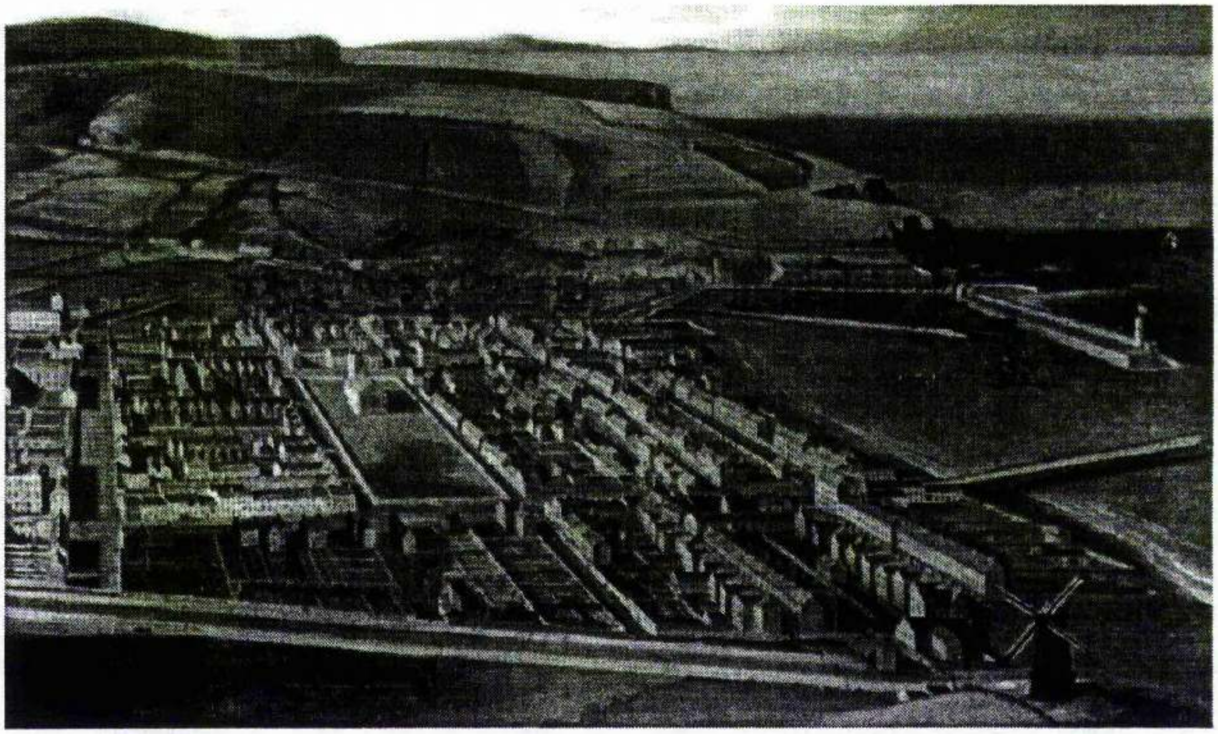
the bowsprit was gammoned. Her foremast would have carried course, topsail and topgallant sail; her mainmast would have had a topsail and topgallant sail and, probably, a choice of mainsails. When sailing on the wind, she would have flown her driver mainsail, set on a boom and gaff; when running free she probably would have set a square mainsail. In addition, she would have carried a spritsail on a yard beneath the bowsprit. Auxiliary sails would have included one or two headsails, a combination of staysails, and studding sails for all squaresails.

A Brief History of the Betsy

As discussed above, the *Betsy* was built in the port of Whitehaven, in Cumberland (now Cumbria) County, in 1772, for employment in the coal trade. Around the middle of the eighteenth century, not long before the *Betsy* was launched, Whitehaven was one of the leading coal and coal-ship producing ports in Great Britain (Figure 6.18).

Betsy was the property of her master, John Younghusband, and his crew. From spring through fall each year she carried Cumberland coal to Dublin, making a trip every six or eight weeks (*Cumberland Pacquet*, 1774-77). Sometime during 1780, she was leased as a naval transport. She was probably leased in Whitehaven, then taken directly to Cork, Ireland, where she was surveyed and enrolled by a Navy Board agent before being placed into service as a victualler. This supposition is based on the fact that Navy Board records list the *Betsy* as a victualler (a transport for food supplies) and Cork was the principal victualling port. She was probably designated a victualler because of her relatively small size; she probably carried general supplies as well as food products.

At some point in time she was assigned to a convoy bound for North America, where she eventually joined Cornwallis's fleet at Portsmouth before ferrying troops to Yorktown. While at anchor at Yorktown, her crew was apparently employed in the fabrication of material for the earthworks ashore and in the repair of cooperage, shoes and other items.



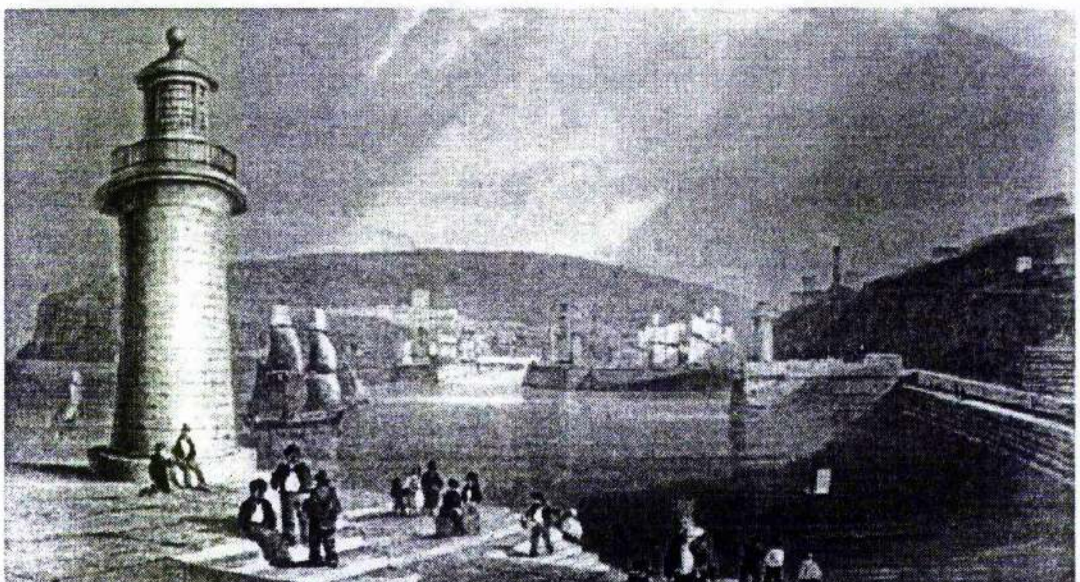


Figure 6.18. Two early views of Whitehaven: the upper view shows the town in 1736, near the peak of its shipping and coal production; in the lower view, dating to the nineteenth century, can be seen a small brig very similar to the Betsy *(courtesy of the Whitehaven Museum, Whitehaven)*

Evidence suggests that in September *Betsy* was drawn into the "sinking line" in front of Yorktown and scuttled along with other transports (Figure 6.19). She was sunk by a single hole cut into her starboard side just below the lower deck. She struck the bottom twenty feet down, where she began to settle into the soft, deep silt below her keel. Although some of the vessels were scuttled in shallow water where their decks apparently remained above the water's reach, geological evidence suggests that *Betsy*'s hull was completely submerged (Johnson 1995). With her broad, flat bottom, she settled on an even keel and slowly began to fill with current-borne silt.

Lying with her decks only a few feet beneath the water's surface, it is likely that some of her fittings, stores and cargo were salvaged by breath-holding divers. At the same time, shipworms would have begun attacking her upper works while strong currents and storms worked her timbers loose. However, as her lower hull settled further into the soft

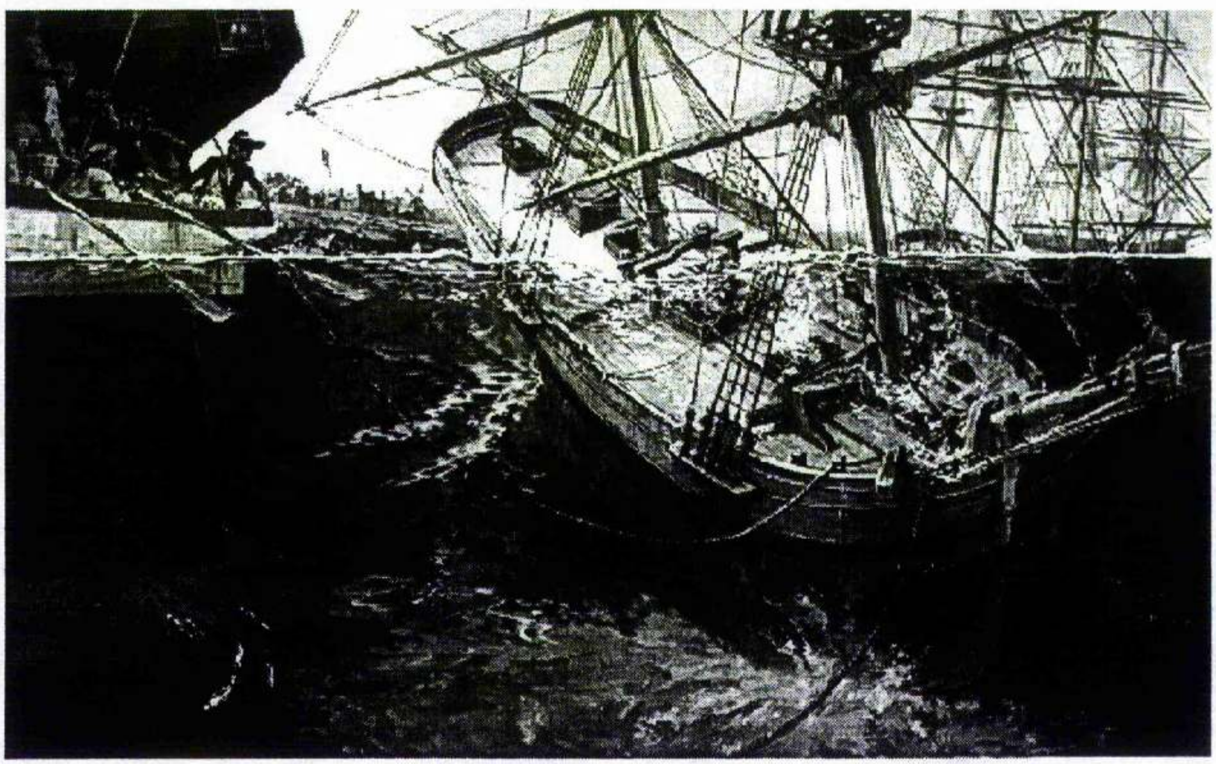


Figure 6.19. Artist's interpretation of the sinking of the Betsy, *(Copyright © 1988, Roy Andersen, National Geographic Society)*

river bottom and her interior accumulated additional silt, she began to stabilize. Within a year, all visible evidence of *Betsy* had probably disappeared (Schoepf 1782). Beneath the bottom of the murky York River, covered and preserved by the fine, protective silt, lay the remains of *Betsy*'s hull and contents, awaiting a distant resurrection.

Summary

The Yorktown Shipwreck Archaeological Project produced significant information on eighteenth-century naval architecture and technology, hull construction details, rigging, stores and cargo. In addition, the research produced a more complete picture of the Battle of Yorktown, 1781. Of particular significance to the present study, the project generated a wealth of detailed and accurate data on a merchant vessel of the eighteenth century.

Contemporary sources and archaeological data were heavily utilized in the identification of shipwreck 44YO88 as the *Betsy* and the interpretation of *Betsy*'s hull remains. She was described with reference to available information on merchant vessels, especially colliers, in an effort to contrast and compare construction and layout details and identify transitional characteristics and possible modifications and repairs.

The resulting lines drawings were put to the test in England when, in 1995, Malcolm Wilson's full-rigged, plank-on-frame model of the *Betsy* was built in Cumbria, utilizing specifications from the Yorktown project and the present study. The model-builder reported that the author's lines drawings and the construction details generated by the Yorktown Project produced a fair hull which, after slight alterations to the stern, was easily planked. The final lines presented herein will eventually be adjusted to take these stern modifications into account, since this portrait of the *Betsy* is an image that grows sharper and more detailed with every added bit of research.[9]

Notes on Chapter 6

[1] The author hopes that readers will not be offended by the occasional references to ships in the feminine gender; it is a longstanding practice, and one that seems appropriate for this study.

[2] The project archives is in the Research Library of the Virginia Department of Historic Resources, Richmond, Virginia.

[3] The author is indebted to several persons, especially David Lyon, David MacGregor and John William Morris III, who provided assistance with the reconstruction.

[4] Notable exceptions include Goldenberg, 1976; Lavery, 1988; and, especially, MacGregor, 1985.

[5] The completed model is a central focus of a permanent exhibit on the Yorktown Shipwreck Archaeological Project, located at the Yorktown Victory Center, Yorktown, Virginia; the author was a major advisor on this exhibit, that also features a unique full-size depiction of an underwater scene of the *Betsy*'s bow during excavation.

[6] The description of construction presented here is far from complete, and is included to give the reader a general picture of the construction process.

[7] The "pink" type of stern is one of the stern forms that sometimes causes the vessel to be referred to as a "double-ender;" the pink stern may have its origins in Dutch shipbuilding tradition.

[8] The reconstructed lines were created using the seven sets of mould frames identified during the excavation as key stations represented on all three views. Eventually, the lines drawing will be revised to the conventional form, that is, with evenly-spaced stations on the shear plan, centered on the projected "midships bend."

[9] This type of project never really ends for the principal investigator; additional research and publications are already being planned.

Part III

Additional Analysis and Conclusions

It cannot be denied that the art of constructing ships ... is the least perfect of all the arts ... the largest ships are often the most defective; and more good ships are seen amongst the merchantmen than in the royal navy.

-- Paul Hoste

Théorie de la Construction des Vaisseaux (1697)

In looking at the progress of naval architecture, we see that theory has been scarcely an object of study in England; and we are forced to the inference that an adequate cause must have existed for the prevailing indifference to science. The cause has prevailed, and continues to exist; for, to a great extent, the effect still exists.

-- John Fincham

A History of Naval Architecture (1851:lxxxiii)

We should not be surprised to find a variation in the proportions of merchant vessels, when we consider there has never been any established rule given for these dimensions, and that they are built by persons who are rivals in trade, and endeavour to keep their principles to themselves, if they think them superior to their neighbours.

-- Peter Hedderwich

A Treatise on Marine Architecture (1830:146)

Part III
Additional Analysis and Conclusions

In Part III, data from archaeological sites around the world are analyzed with respect to results and conclusions from the Yorktown shipwrecks; then, all archaeological and historical information collected during the present study is combined to construct a comprehensive image of English merchant vessels from the eighteenth century.

Chapter 7 presents information on other relevant shipwreck sites and extant historic vessels, based primarily on published reports and drawings but supplemented by this author's personal knowledge of several of the sites as well as communications with the respective project archaeologists and historians. The interpretation of the collier brig *Betsy*, presented in Part II, serves as a source of comparison, since *Betsy* is one of the few well-preserved examples of eighteenth-century English merchant vessels. Chapter 8, the final chapter, draws from all sources of documentary and archaeological data in describing the evolutionary trends in English merchant vessels from the eighteenth century. The wide range of data provide a foundation from which to build a more complete picture of the hull form and construction of those merchant vessels. Finally, suggestions are offered for a continuation of this study.

Chapter 7

Comparative Archaeological Evidence

A surprisingly large number of shipwrecks from the seventeenth to nineteenth century have been discovered and documented, especially in the last two decades. However, few of these sites provide pertinent information for the present study. Many of the vessels are completely unrelated types (non-European craft, flat-bottomed inland craft, warships, Indiamen, etc.), and many are so poorly preserved or so incompletely documented that useful comparisons can not be made. Nevertheless, listing relevant sites that have been discovered and, to some extent, documented, proved useful in defining the available resource base. Table 7.1 is a representative list of archaeological sites from the two centuries of primary interest, essentially from the mid-seventeenth to the mid-nineteenth century. Table 7.2 is a similar list of extant vessels or vessel remains from the same time period.

Referring to Table 7.1, the first nine shipwreck sites are particularly relevant to the present study. The first site, the *Betsy*, was described in the preceding chapters and is listed here only for comparison. The next four sites on the list are discussed below in detail; the last four, although offering great promise, have not been sufficiently excavated and documented to permit detailed comparison. Wrecks from the second group in Table 7.1 have been fully or partially documented, and they appear to date to approximately the eighteenth century, but no specific age or origin can be attributed to them with certainty. The third group is made up of identified wreck sites for which at least some information is known,

TABLE 7.1
SHIPWRECKS

VESSEL/SITE NAME	SITE LOCATION	DATE BUILT/TYPE/SIZE	ADDITIONAL DATA
Betsy	**Yorktown, VA**	**1772, brig, 176 tons**	**English collier** (see Chapter 5)
Slufter Collier	Netherlands	*c.* 1840, brig (?), c. 300 tons	English collier
Bermuda merch.vessel	Bermuda	3rd Qtr. 18th/c?, c. 220 tons	English (*Industry*, 1765 ?)
Ronson Ship	New York	*c.* 1720, ship (?), c. 260 tons	British-American (?) merchant
Defence	Maine	1778, brig, 170 tons	United States privateer
General Carleton	Poland	1777, Whitby, 500 tons	English merchant vessel
Yorktown YO89	Yorktown, VA	1781, ships(?), 350 tons	Engl. merch. vessel (See Ch. 4)
Yorktown YO94	Yorktown, VA	1781, ships(?), 430 tons	Engl. merch. vessel (See Ch. 4)
Seaton Carew wreck	Hartlepool, UK	1st half 19th/c (?), 240 tons (?)	British collier (?)
Crosswicks Creek Site	New Jersey	3rd qtr. 18th/c (?), 100 tons (?)	U. S. merch/privateer (?)
Deadman's Island Site	Florida	3rd qtr. 18th/c (?), 110 tons	British warship (?)
Fig Island Wreck #2	Georgia	late 18th/c (?), 200 tons	New England ship/bark (?)
Fig Island Wreck #20	Georgia	late 18th/c (?), 250 tons (?)	New England ship/bark (?)
Old Fields Beach Site	Assateague, VA	1st half 19th/c (?), 250 tons (?)	British-American (?) merchant
Amsterdam	Hastings, UK	1748, ship	Dutch East Indiaman
Dartmouth	Sound of Mull, UK	1690, 266 tuns [old meas.]	British 5th rate, built 1655
El Nuevo Constante	Louisiana	1766, ship, 470 tons	British-built merchantman
Hamilton/*Scourge*	Canada	1814, armed schooners	British-Canadian (U.S.)
Kraken	Sweden	1651, (?)	Swedish-built
San José	Florida	1733, merchantman (?)	British-built

TABLE 7.2
EXTANT VESSELS OR VESSEL REMAINS

VESSEL/SITE NAME	VESSEL LOCATION	DATE BUILT/TYPE/SIZE	ADDITIONAL DATA
Slufter Collier	Netherlands	*c.* 1840, brig (?), c. 300 tons	English collier
Ronson Ship (Bow only)	New York	*c.* 1720, ship (?), c. 260 tons	British-American (?) merchant
Brown's Ferry	South Carolina	c. 1750	Colonial-built coasting vessel
Constellation	Maryland	1797, 44-gun frigate	United States
Constitution	Massachusetts	17??, 44-gun frigate	United States
Eagle	New York	1814	United States schooner
Lutina (?)	Netherlands	late 19th/c, merchant vessel	Dutch
Philadelphia	New York	1814, gondola	U.S. gunboat
Sparrow Hawk (?)	Massachusetts	1626, ketch	English
Ticonderoga	New York	1814, armed schooner	United States
Trincomalee	Hartlepool, UK	1817, 46-gun frigate, 1066 tons	British (built in Bombay)
Unicorn	Dundee, UK	1834	British
Victory	Portsmouth, UK	c. 1805, warship	British 1st Rate warship

even though not all are directly relevant to this study. Several lake vessels from the War of 1812 have been included in this study for comparison.

Table 7.2 lists a wide range of vessels from the period of interest that are still extant or at least partially preserved and available for examination. The first two are listed in both tables, since portions of their bows were recovered, conserved and retained. The rest of the examples are listed alphabetically. Some of these, such as the Brown's Ferry Vessel and *Philadelphia*, are shipwreck remains that have been recovered and, to some extent, preserved; others, including the *Constitution* and *Victory*, are surviving vessels. Although many of these vessels and shipwrecks offer useful comparisons, the information is somewhat limited. The shipwreck remains are incomplete, while the extant vessels have, over the years, undergone extensive and repeated repairs and alterations, making it difficult to ascertain which portions represent original construction. Nevertheless, these vessels add an extra dimension to the documentary sources on ship construction and, therefore, this chapter attempts to glean from this source as much relevant comparative information as possible.

FOUR COMPARATIVE STUDIES

Four shipwrecks are particularly relevant to the present study and will be examined in detail. Two may be English colliers from the eighteenth or nineteenth century, a third is a ship probably built in British America in the early eighteenth century and the fourth, the *Defence*, is an American privateer from the American War for Independence. In all four cases the sites included relatively well-preserved hull remains and all were well documented by archaeologists.

The Slufter Collier, *ca.* 1840

In August, 1986 the Slufter Project, a large-scale dredging project for the port of Rotterdam, encountered several shipwrecks, one of which is remarkably similar to the Whitehaven collier *Betsy*, that sank some sixty years earlier in Yorktown, Virginia (see the previous two chapters). Slufter Shipwreck Site SL4 was discovered when it was struck by the project's cutter-suction dredger on August 24, 1986. A preliminary assessment by the archaeology team revealed a wooden vessel over 65 feet (20 m) in length and in extremely good condition.[1] The hull appeared to be relatively intact up to a deck and a hatch, and the hull was filled with large lumps of coal. A few loose objects were recovered for analysis. Archaeologists concluded that SL4 was a nearly-intact English collier, built *ca.* 1838 and sunk *ca.* 1845 while transporting a cargo of coal presumably destined for Rotterdam. Because of the relatively recent date of the vessel and the very rigid dredging schedule, the wreck had to be abandoned archaeologically. Fortunately, however, the wreckage also had to be removed and, as a result, a significant portion of the vessel's bow was recovered nearly intact and, along with numerous disarticulated timbers, was completely recorded and reported by the on-site archaeology team (Adams *et al.* 1990:71-132). A representative section of the hull was removed, conserved and may have been placed on exhibit at the Prinz Hendrick Maritime Museum, Rotterdam (Adams 1997:pers.comm.).

As shown in Figure 7.1 the articulated remains of SL4 consisted of the bow almost as far aft as the midships bend, but missing the stem and most of the apron; a section of the keelson was still attached, as was the stump of the foremast (*Ibid.*). Figure 7.2 highlights details of the keel, floors and keelson. At approximately midships, the keel measured 11" sided by 14-15" molded. The keel, which was made up of at least four birch segments, was estimated to have originally been 79-82' long. There was no evidence that a false keel (shoe) had been attached.

The heavy oak floors were 11-12" square and set on 1'11" centers. The heels of the first futtocks were set clear of the keel and the futtocks were joined together with chocks. In some cases side-by-side futtocks were bolted together to form paired frames, but none of the floors and first futtocks were fastened together. The bow was formed with radial cant frames, at least two of which were through-bolted to form a paired frame. As can be seen in Figures 7.1 - 7.3, the keelson consisted of two timbers, 11" wide, one over the other, tapering at their forward end and bolted through the floors and keel with 3/4" iron bolts. The planking was 10-12" wide and $2^1/_2$-$3^1/_2$" thick; lower strakes are elm, while upper ones are oak. The ceiling, averaging 10-11" in width and $2^1/_2$" in thickness, was all oak. The $4^1/_2$' long pine foremast stump was $15^3/_4$" in diameter at its widest point and had a metal band near its base.

SL4 and the Whitehaven collier *Betsy* (see previous two chapters) shared a number of similarities in framing. Figure 7.4 is a schematic representation of the typical framing pattern on the *Betsy*. A comparison of the *Betsy*'s framing with that of SL4, as illustrated in Figures 7.2 and 7.3, shows that the first futtocks of both were constructed with chocks that

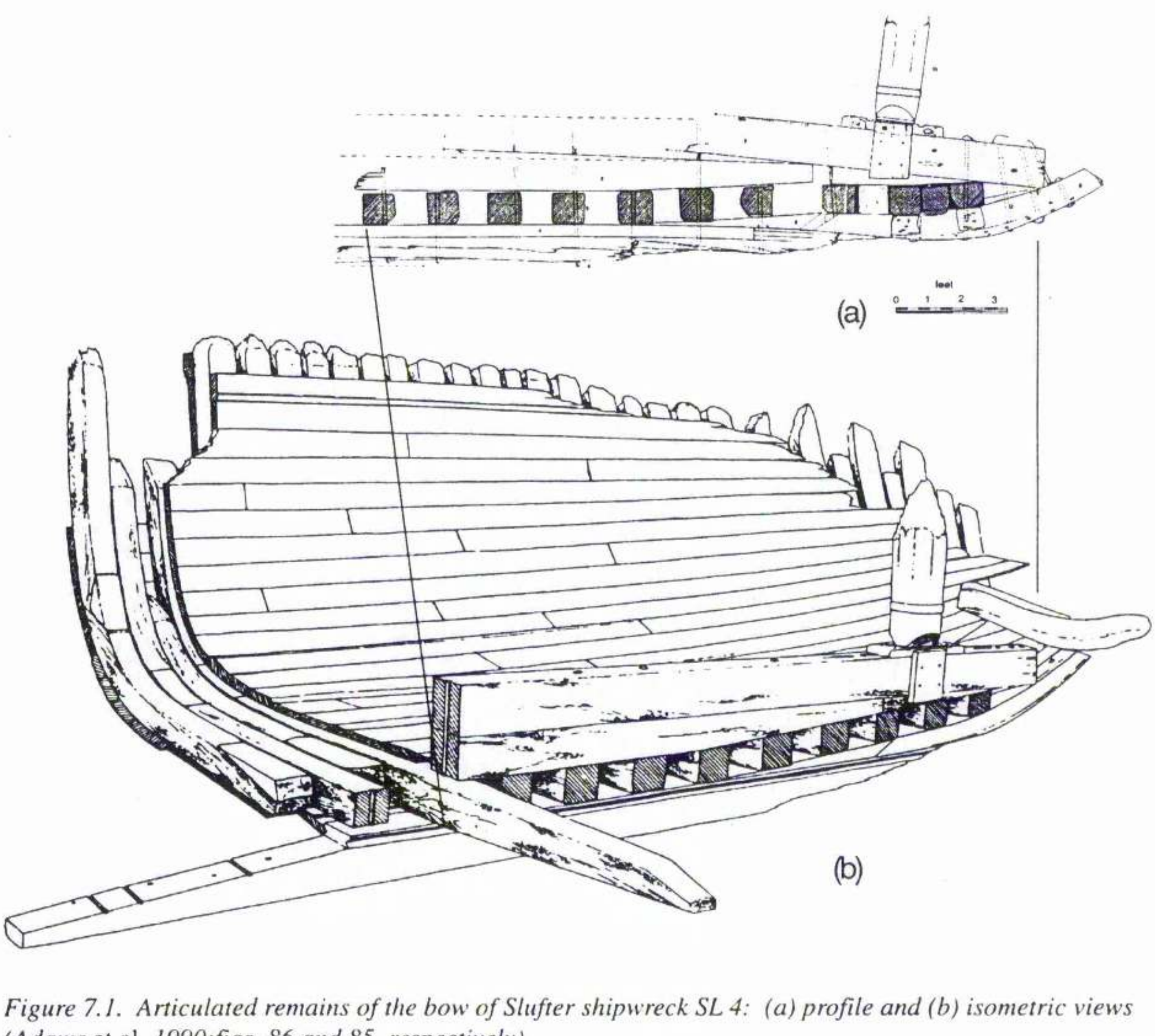


Figure 7.1. Articulated remains of the bow of Slufter shipwreck SL 4: (a) profile and (b) isometric views (Adams et al. *1990:figs. 86 and 85, respectively)*

Figure 7.2. Slufter shipwreck SL 4: Detail of keel, floor and keelson (Adams et al. *1990:fig. 89)*

1. Bilge planks
2. Ceiling planks
3. Limber strake
4. Limber board
5. False keelson
6. Keelson
7. Floor timber
8. Outer planking
9. Garboard strake
10. Pine board
11. Keel
12. Chock
13. First futtock
14. Stopwater

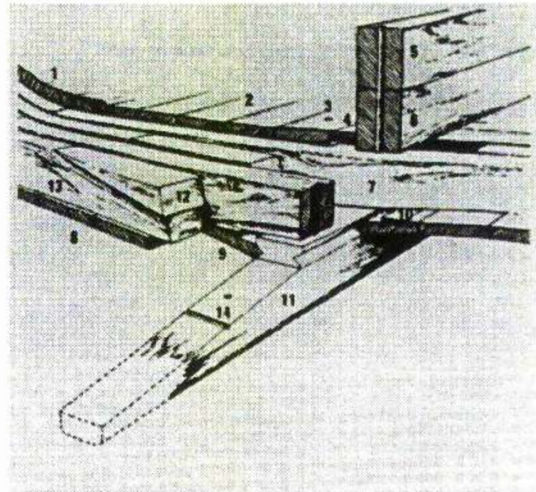
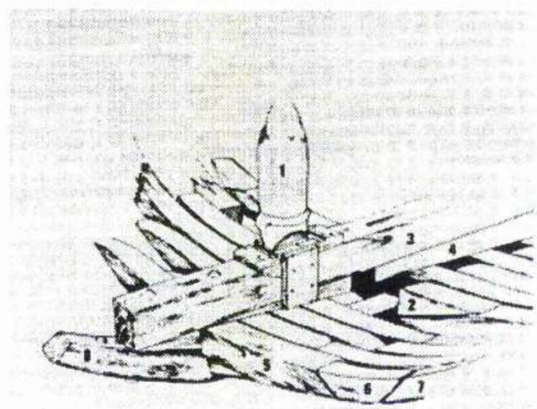


Figure 7.3. Slufter shipwreck SL 4: Bow construction (Adams et al. *1990:fig. 90)*

1. Mast
2. Chock
3. False keelson
4. Keelson
5. Floor timber
6. Chock
7. First futtock
8. Apron
9. Deadwood
10. Keel



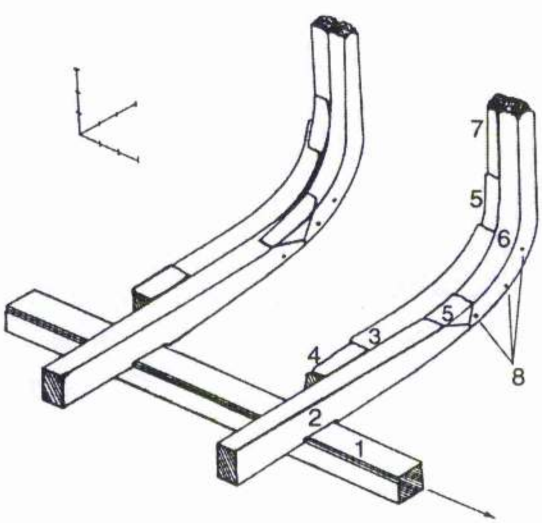


Figure 7.4. Schematic representation of typical framing on the Betsy *(Broadwater)* *

1. Keel
2. Floor timber
3. First futtock
4. Chock
5. Chock
6. Second futtock
7. Third futtock
8. Through-bolts

* Note: intermediate frames not shown

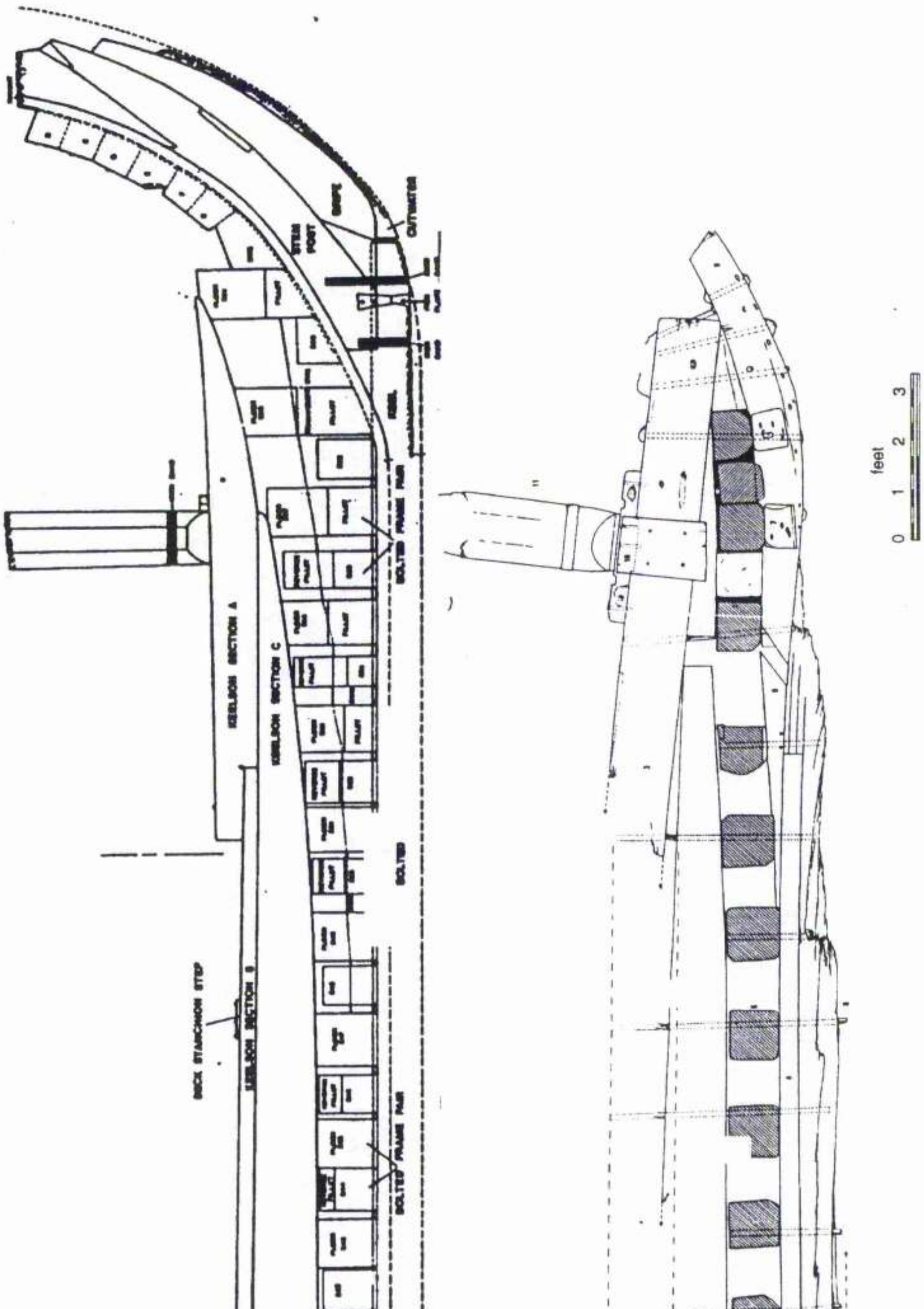


Figure 7.5. Comparison of the bows of the Betsy (top) and Slufter shipwreck SL4, shown at the same scale (SL4 drawing from Adams et al. *1990:fig. 86;* Betsy *drawing by J.W. Morris III)*

filled out the futtock heels to the required thickness. Both also had their first futtocks set off from the keel an average of nearly a foot, a fairly standard technique for the construction of merchant vessels, as it provided a large sump and watercourse in the bilge to prevent water damage to the cargo. In both vessels, futtocks were scarfed together with triangular chocks, a typical pattern for the eighteenth century but assumed to be virtually abandoned by the early nineteenth century. The chocks of SL4 (#6 in Figure 7.3) were less standard, however; the futtocks were cut so that the chock filled a gap that completely separated the futtocks. Conventional chock scarfs leave approximately one-third of the surfaces of the futtocks in contact with each other. The framing of both vessels shared another characteristic, that of having only a few frames through-bolted to form compound, or paired, frames, and even those frames had no bolts joining their floors and first futtocks.

Figure 7.5 compares the bows of the *Betsy* (upper) and SL4 at the same scale. There are similarities, including a metal band encircling the base of each mast, keelsons that taper at their forward ends, rider keelsons and keels with no false keel. However, where SL4 had a full-size rider keelson, *Betsy* had a very thin rider scarfed into a thicker rider in the vicinity of the foremast. *Betsy*'s foremast was stepped directly into this rider, labeled Keelson Section A; SL4 also had its foremast stepped into its rider keelson, but a step structure was built up at that point to strengthen the step and support the heel of the mast. Unfortunately the remaining bow components are missing from SL4 making it impossible to determine if it originally incorporated *Betsy*'s unusual horizontal "apron chocks" in its construction. Such is not likely to have been the case, but the discovery of such unusual bow features in another vessel would be quite significant.

Table 7.3 compares the principal scantlings of SL4 and the *Betsy*. Based on this comparison, the estimated original keel length and the position of the foremast, the present study suggests that SL4 was probably a brig of just over 300 tons burthen.[2] It is interesting to note that although the *Betsy* was barely more than half the size of SL4 its scantlings were as large or larger.

TABLE 7.3
COMPARISON OF SCANTLINGS OF THE BETSY AND SLUFTER SL 4

Scantling	*Betsy*	SL 4
Keel: sided	14 3/8"	11"
molded	13 1/4"	14-15"
False Keel (Shoe)	none (?)	none
Keelson: sided	14 3/8"	11" (with rider
molded	15 5/8"	of same size)
Floors: sided	11-14"	11-12"
molded	14-16"	11-12"
Outer planking: thick	3 1/2"	2 1/2-3 1/2"
wide	8-12"	10-12"
Ceiling planking: thick	2 1/2"	2 1/2"
wide	8-11"	10-11"
Estimated Tonnage	**176**	**300?**

The Bermuda Merchant Vessel

In 1993 a team of archaeologists and students from the Program in Maritime History and Nautical Archaeology at East Carolina University, Greenville, North Carolina, investigated a shipwreck just beyond the outer perimeter of shallow reefs on the western side of the Bermuda archipelago. The site (figure 7.6) lay on an east-west axis in 29 feet of water and consisted of a large mound of ballast stones with hull timbers protruding from each side. The preserved length of the keel was 69' 9" and the maximum preserved width of the preserved hull was 24 feet. The ballast mound had apparently remained relatively undisturbed, although the wreck at both extremities had been previously uncovered by salvors seeking artifacts (Watts and Krivor 1995:97-98).

The archaeology team cleared overburden from the hull at both ends where the site had been previously disturbed, recovered several artifacts for dating and identification purposes, and recorded all exposed hull components; the remaining portion of the site was left undisturbed. Following the investigation, the exposed elements were reburied (*Ibid.*:98-99).

The hull was heavily framed. The keel was elm and measured 16" sided and just over 12" molded. Fayed to the upper face of the keel was a rising wood timber, or deadwood (the authors use the term "hog"). This timber was $19^{1}/_{2}$" sided, maximum breadth, by 10" molded. The frames were white oak and averaged 12" sided by 12-13" molded; each had an oak fillet fayed to the underside of its head (Figure 7.7). The oak first futtocks were offset from the keel by $6\text{-}8^{1}/_{2}$" and each had an oak fillet on the upper face of its head. The floors and second futtocks were joined by a simple diagonal scarf. No chock scarfs were observed. In the few frames that could be observed no through-fasteners were found; further excavation will be required to determine if futtocks were through-fastened to form mold frames. The keelson was fashioned from oak and measured 18" sided by $12^{1}/_{2}$" molded. Hull planking was oak and was 3" thick, with widths ranging from $11^{7}/_{8}$ to $12^{1}/_{4}$ inches. The lower hull was coated with felt and pitch, then sheathed with 1" pine boards.

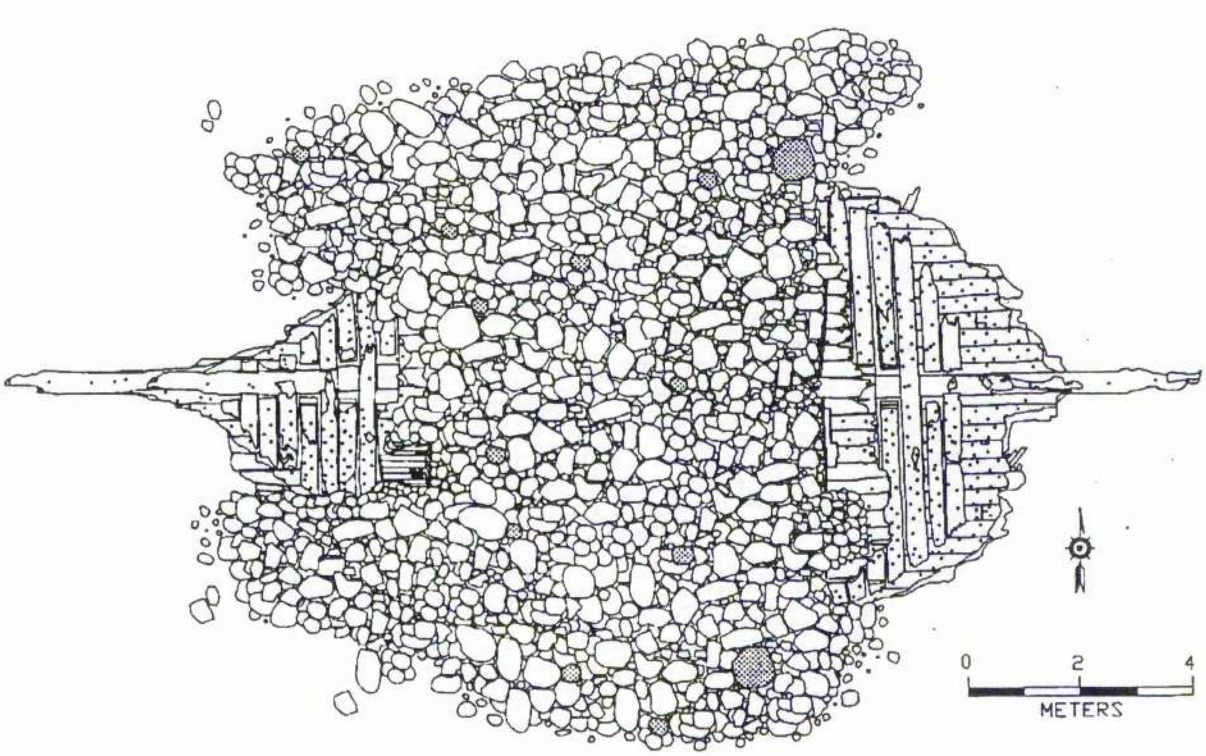


Figure 7.6. Site plan of the Bermuda merchant vessel (Watts and Krivor 1995:103).

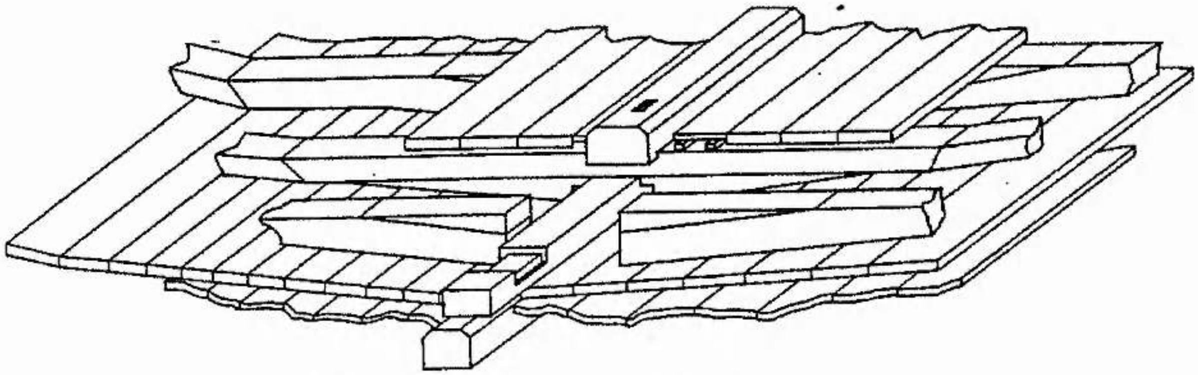


Figure 7.7. Schematic framing pattern for the Bermuda merchant vessel (Watts and Krivor 1995:103).

Artifacts recovered during the project, especially glass and ceramic fragments, a pewter candlestick and buttons, suggest that the vessel was English and that it sank during the last quarter of the eighteenth century. Using the standard tonnage formula employed throughout this study, and the basic site dimensions (Ibid.:100), the capacity of the vessel can be computed as follows:

$$T = 70 \times (24)^2/188 = 214.5 \text{ tons burthen,}^3$$

where 70 represents the preserved keel length in feet and 24 the preserved beam in feet. The keel is broken at the stern, thus would originally have been longer; however, the width of the wreck might be exaggerated due to flattening of the hull. A reasonable estimated tonnage range, therefore, is 200-250 tons.

An examination of historical records identified nearly thirty English vessels lost in Bermuda from 1770 to 1796. Of those matching the estimated wreck tonnage, one possibility identified by the authors is the *Industry*, an English merchant brig that struck a Bermuda reef on April 14, 1774, and was declared a total loss (*Ibid.*:107). At the time of its sinking the *Industry*, under the command of John Lowes, was in service as a Royal Navy transport. Fortunately for this study, the *Industry*'s lines were taken off at Deptford Dockyard in December, 1765, presumably after its purchase for use as a transport, and the author's files include a complete set of plans for the *Industry* (NMM:Box 63; see the previous discussion of the *Industry* in Chapter 3).

Dimensions on the plans are as follows:

Length on the Range of the Deck	83' 9"
Length on Keel for Tonnage	60' 11"
Breadth Extreme	24' 7"
Depth in Hold	12' 8"
Burthen in Tons	$221^{50}/_{94}$

In an effort to confirm the identity of the Bermuda shipwreck, the present study aligned the wreck site plan with the sheer plan of the *Industry* (NMM: Box 63, Draught No. 6429) (Figure 7.8). The alignment was accomplished by lining up the stem scarf on the wreck with the projected corresponding scarf on the *Industry*'s draught.[4] Shown above the sheer plan is the Navy Board's proposed arrangements draught of March, 1766 (NMM:Box 63, No. 6836), which probably most closely represents the *Industry*'s configuration when it sank in 1774. Among the alterations depicted on the Deptford plans: a lower deck was added (or an existing lower deck, not shown on the original sheer plan, was reinforced); the hull was pierced for six 24-pounders and eight swivels;[5] the foremast was moved forward approximately two feet; a knee and bitts were added to support the bowsprit; additional shrouds and backstays were added to reinforce the masts (no spar dimensions were given, but it is likely that the sail area was increased); railing was added along the entire range of the upper deck; platforms were added below the lower (gun) deck for stowage and for the magazine. A separate draft detailed the new deck arrangements (NMM:Box 63, No. 6837). Undoubtedly, the *Industry*'s survey report, valuation and alterations are detailed in the Deptford Dockyard records (PRO ADM 106), and those records would be of considerable value for this identification process; however, those records are not indexed and would require a search of the dockyard books for 1765-1766. *Lloyd's Register of Shipping* is very incomplete for the 1760s, and the only surviving volume before 1765, when the *Industry* was purchased by the Navy Board, is 1764, in which all entries have been lost before the letter "M." Since the *Industry* was purchased, not leased, it was no longer insured and, therefore, does not appear in later volumes of *Lloyd's*, which does not list Royal Naval vessels.

Unfortunately, as seen in Figure 7.8, comparison of the Bermuda hull remains to the *Industry*'s draughts does not provide confirming evidence. The preserved keel length of the Bermuda wreck is less than that of the *Industry* by approximately 6-7' which leaves the *Industry* as a viable possibility, but offers no proof; the upper area of the keelson where the foremast step would have been located is eroded away on the Bermuda site, and the mainmast step/pump area is covered by ballast stone. A very small amount of excavation in the mainmast area should reveal the pump well and possibly the step, which would be impor-

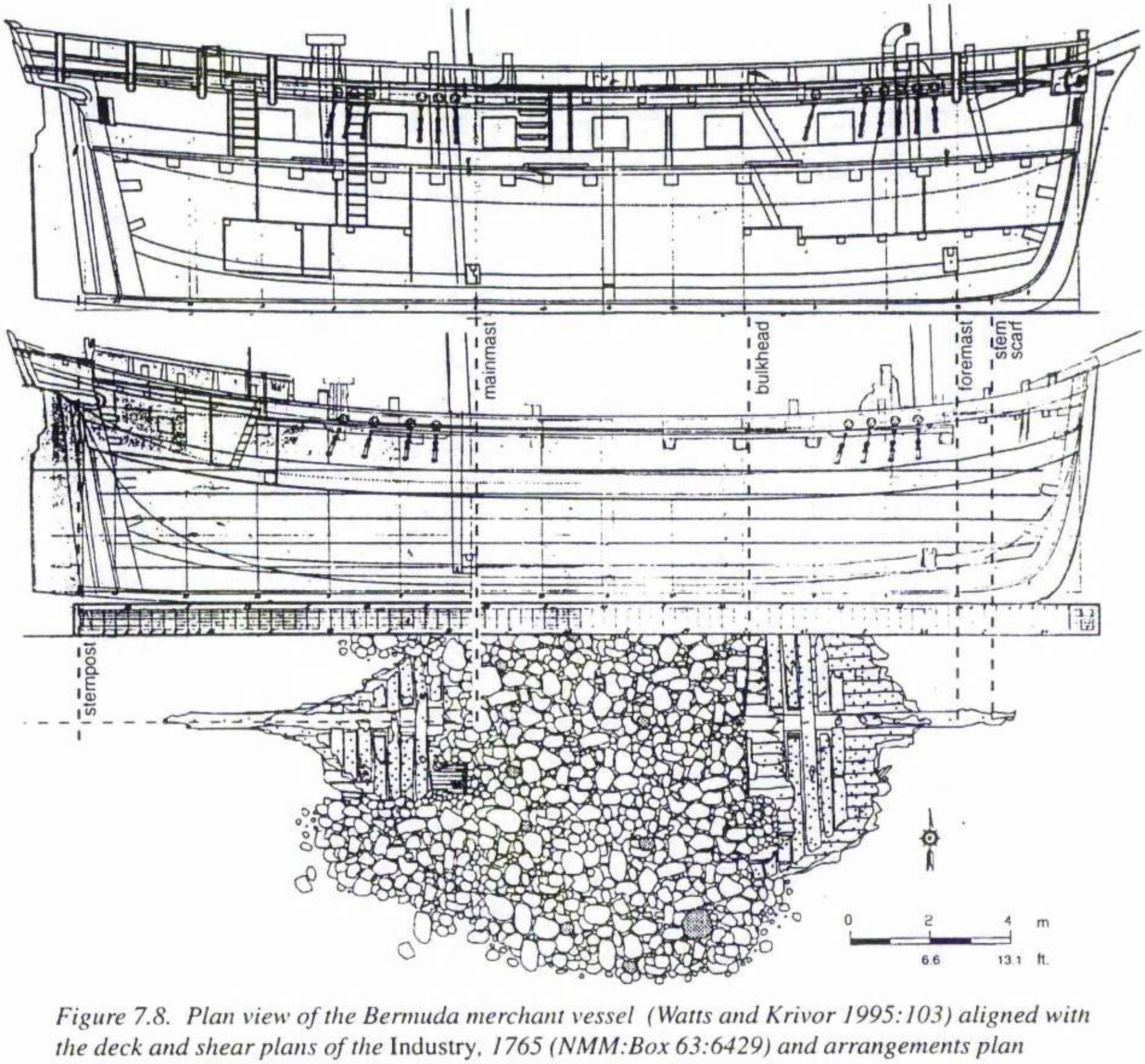


Figure 7.8. Plan view of the Bermuda merchant vessel (Watts and Krivor 1995:103) aligned with the deck and shear plans of the Industry, *1765 (NMM:Box 63:6429) and arrangements plan (NMM:Box 63:6836), to the same scale.*

tant in identifying the Bermuda site as the *Industry*. Recent research by M.Krivor (1997:pers.comm.) suggests the *Industry* was salvaged, which, if verified, would obviously eliminate this vessel from consideration. Hopefully, a future expedition will be able to positively identify the wreck. If it can be verified that the Bermuda wreck is the *Industry* brig or another well-documented vessel, and if further excavations can be conducted, the research would contribute extremely valuable evidence on the construction details of eighteenth-century English merchant vessels.

The Ronson Ship

In January, 1982, an archaeological survey of a proposed building site in lower Manhattan, New York City, produced a surprising find: a nearly intact wooden ship, completely buried 12 feet beneath city streets. The developer, Howard Ronson, allowed the archaeology team an extra 30 days to excavate and record the ship; a team of 45 people was quickly formed (Riess 1987a:185-186; Riess 1987b:9-12). The hull was excavated and recorded, then a segment of the bow was removed (Figure 7.9) and transported to a conservation laboratory in Groton, Connecticut for treatment (Riess 1987b:18). In 1985, the bow timbers were transferred to The Mariners' Museum,

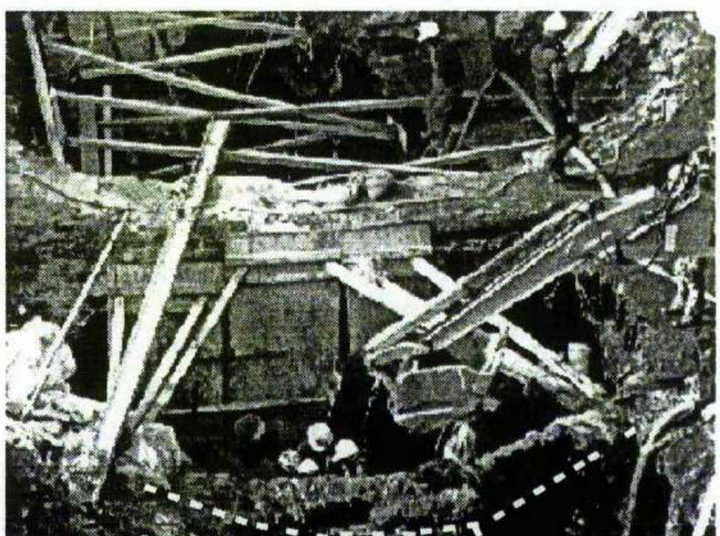


Figure 7.9. Excavating and removing the bow of the Ronson Ship, New York City (the stem and curve of the bow are highlighted by dotted lines (Steffy 1988:127).

Newport News, Virginia, where they were to be reassembled and placed on exhibit (*Ibid.*:12). However, the Museum discovered that the timbers required extensive additional conservation and a suitable treatment facility had to be prepared; it was more than a decade before conservation was completed. The timbers are currently in storage, with plans being developed for their eventual exhibition at South Street Seaport Museum, New York (Pennington 1997:pers.comm.).

Riess provided the following general description of the "Ronson Ship" (Figures 7.9 - 7.11): The ship was extremely well preserved; there was clear evidence that the vessel had stepped three masts and had been ship-rigged (Riess 1987b:21); the hull measured 82' long on the lower deck, had keel length of 68', a maximum beam of 27' and a depth of hold of 7.5' (*Ibid.*:34); it would have been registered in America at between 150 and 210 tons (Riess 1987a:186; Riess 1987b:34); the hull was intact to approximately 3' above the lower deck in the bow and to the lower counter timber in the stern (Riess 1987b:21), and that the lower deck was pierced for at least six 6-pound cannon (*Ibid.*:23); the vessel had a moderately full bow, flat floors and a square tuck stern (*Ibid.*:21). Only a few artifacts recovered from the site could be somewhat confidently associated with the ship's former active period; those objects, along with other evidence, suggested that the vessel was English-owned, was constructed in Virginia sometime between 1710-1720, abandoned around 1730 and buried sometime between 1747 and 1755 (Riess 1987b:46; Riess 1991:29). A provisional set of reconstruction lines (Figure 7.11) was developed by G. Matson from the archaeological site data (Matson, in Riess 1987b:35).

As was the case with the present author, Riess was attracted to the concept of using Chapman's merchant vessel class types (Chapman 1768), as interpreted and defined in a table by MacGregor (1985:29; see Chapter 1 of the present document) as a means of classifying and partially defining shipwreck remains. Riess (1987b:36-39) applied this methodology to the Ronson Ship with mixed results. He initially concluded that the Ronson Ship "fits the description of a frigate, except for its midship area, which is more like that of a bark in the table" (*Ibid*:36); after further analysis at The Mariners' Museum, he revised his evalu-

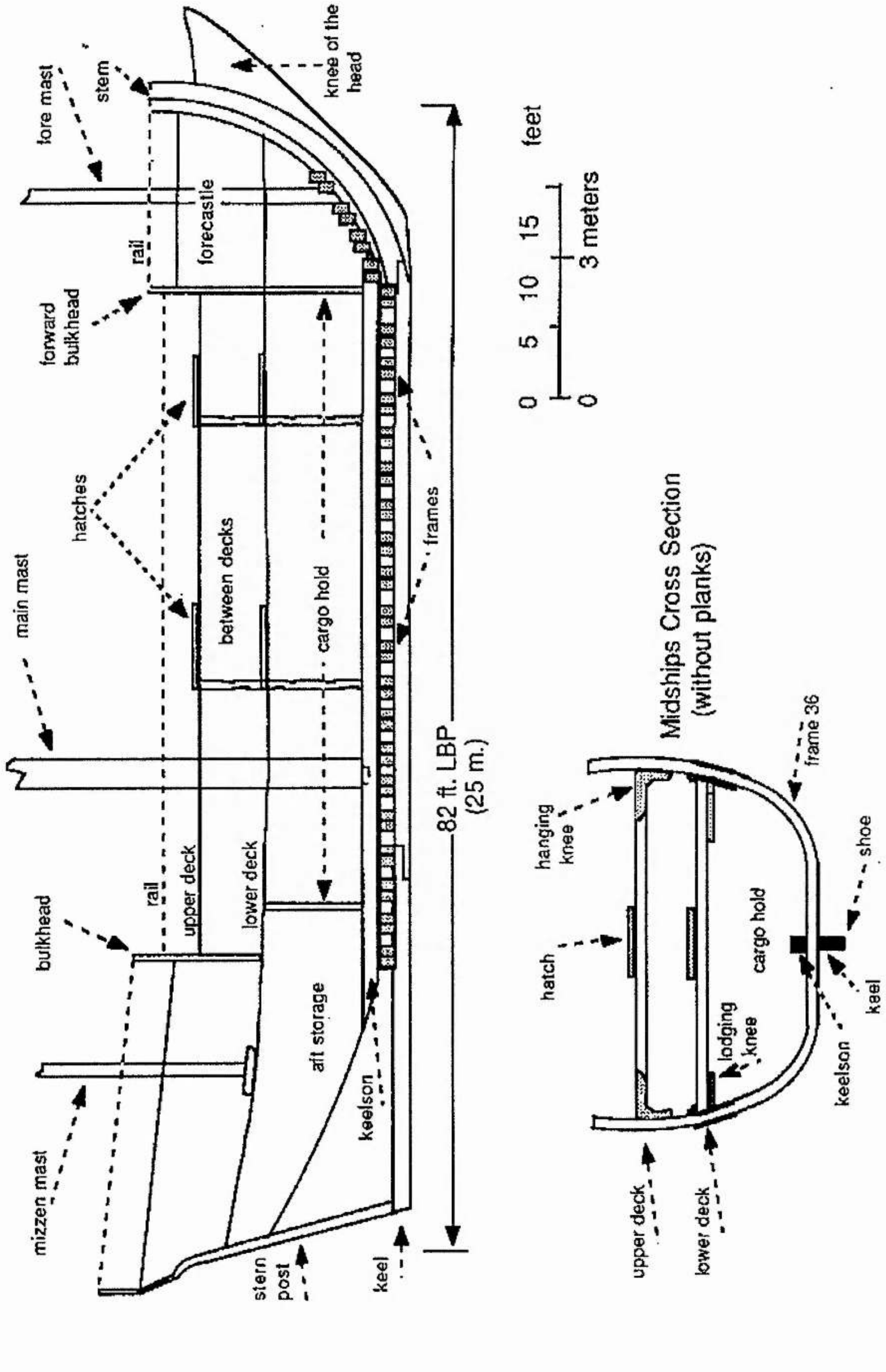


Figure 7.10. Ronson Ship profile and section (Riess 1987b:22).

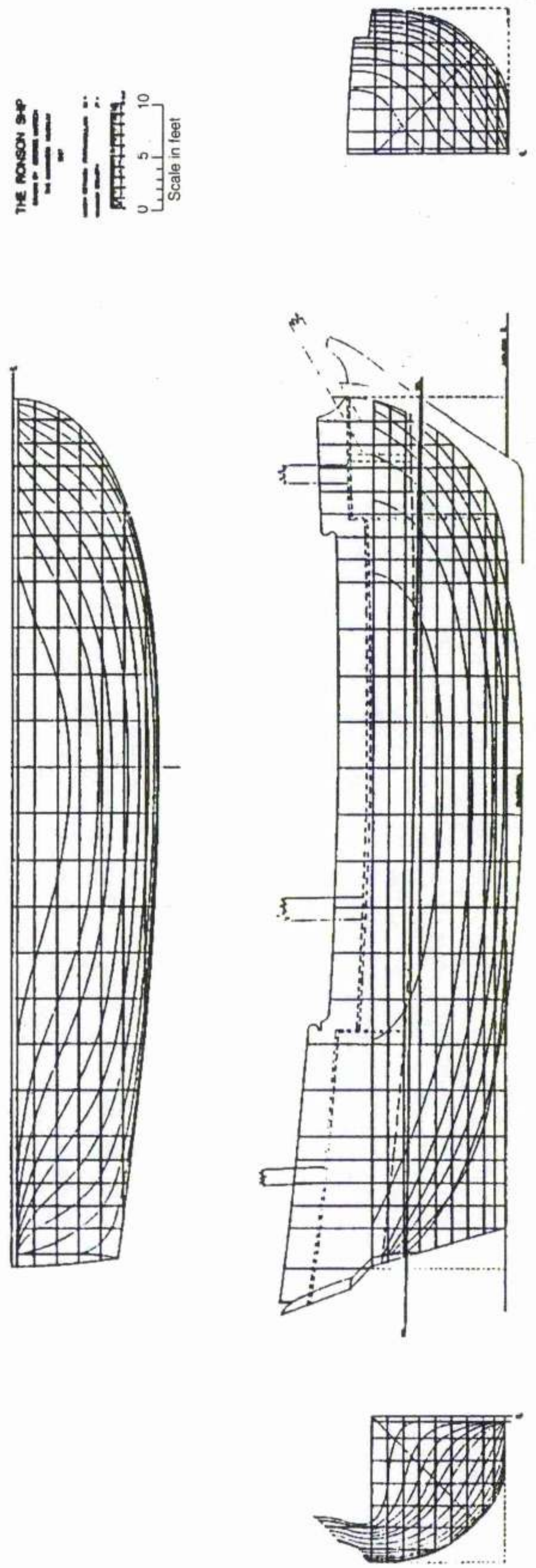


Figure 7.11. Ronson Ship reconstructed lines, drawn by G. Matson (Riess 1987:35). (Note: a scale has been added, since the original is too small to be read at this size.)

ation, stating that the hull appeared to be a merging of the attributes of frigates and flyboats (Riess 1991:179).

In reviewing the drawings and descriptions of the Ronson Ship (Riess 1987a, 1987b and 1991), the present author arrived at a somewhat different interpretation of the vessel. Riess (1987b:21) states that it was three-masted and ship-rigged; however, a bark rig seems equally likely to this author. Its depth of hold was listed at 7.5', which is very shallow for a merchant vessel of this tonnage, and the height of the 'tween decks, as measured from Figure 7 (*Ibid.*:22; Figure 7.10 in this document), is only approximately 4'9", which is extremely cramped for a gun deck. It is possible that the lower deck beams were not originally planked over and that the depth of hold would have been measured to the underside of the upper deck beams, giving a more capacious value of nearly 12 feet. On the other hand, a full lower deck and guns may have been part of the original design; the need to arm the vessel while still maintaining a satisfactory metacenter may have required placing the guns on a cramped lower deck, rather than the weather deck.

Riess (*Ibid.*) concludes that the vessel would have been registered in England at between 220 and 300 tons; however that range can be confidently reduced. Although Figure 7 (Figure 7.10 in this document) depicts a keel length of 68 feet, to the forward end of the stem scarf, it also indicates a total "tread" length of 72 feet, a value sometimes used for computing tonnage burthen. Using 68' as the length of keel for tonnage, yields

$$T = 68 \times (27)^2/188 = 263.7 \text{ tons burthen,}$$

whereas the value of 72' gives

$$T = 72 \times (27)^2/188 = 279.2 \text{ tons burthen.}$$

For comparison with other vessels in the present study, the tonnage was also computed by the present author according to the standard British formula widely used throughout the eighteenth century, with the following results:

$$T = \frac{[82 - {}^{3}/_{5}(27)] \times 27 \times (27/2)}{94} = \frac{65.8 \times 27 \times 13.5}{94} = 255.2 \text{ tons burthen}$$

where 82'0" represents the length on the lower deck and 27'0" is the maximum beam, as given by the author (*Ibid.*:34). Therefore, a more precise tonnage range for the Ronson Ship, using standard British measurement methods is 255-280 tons burthen.

The present author also believes that it would be incorrect to characterize the Ronson Ship as similar to a frigate except for its midship area. Frigates, whether built for war or commerce, were designed for fast sailing, with reasonably fine ends and generally with moderate to significant deadrise (Falconer 1780; MacGregor 1985:31);[6] therefore the characterization "resembling a frigate except with a bark or flyboat midship section" would appear to be relatively meaningless.

Applying the analytical methods described in Chapter 2 of this study, an attempt can be made to produce an alternative interpretation of the Ronson Ship. However, other factors must first be mentioned: the lines drawings printed in Riess 1987b:35, are very small; also, due to the limited excavation time, the lines were taken off hurriedly using the angle-distance method employing a relatively small protractor and tape; and finally, a significant portion of the stern was buried beneath a city street and could not be fully documented (Riess 1987b:17; author's observations 1982). The dendro diagrams developed in Chapter 2 of this study are somewhat helpful, but only in a general way, since the terms are too subjective to consistently identify specific vessel types; also, the diagrams often yield different answers, depending upon the attribute first considered.

Interestingly, however, the dendro diagram analyses of the Ronson Ship conformed somewhat to Riess's conclusions, as shown in Figures 7.12 and 7.13. (Note: it is important to emphasize that the "round" and "square" sterns referred to in the diagrams are as defined in MacGregor (1985:29-30) and indicate where the lower wales terminated; almost all round- and square-sterned vessels had some form of square "tuck" at the counter.) Figure 7.12 simply states that given the two attributes stern shape and type of head, the vessel is likely to be a frigate. Figure 7.13 instead looks at lower hull characteristics, suggesting that the hull shape is that of a bark, or possibly a flute or hagboat. The results depend to a large extent on the interpretation of the person conducting the analysis. It was this ambiguity that

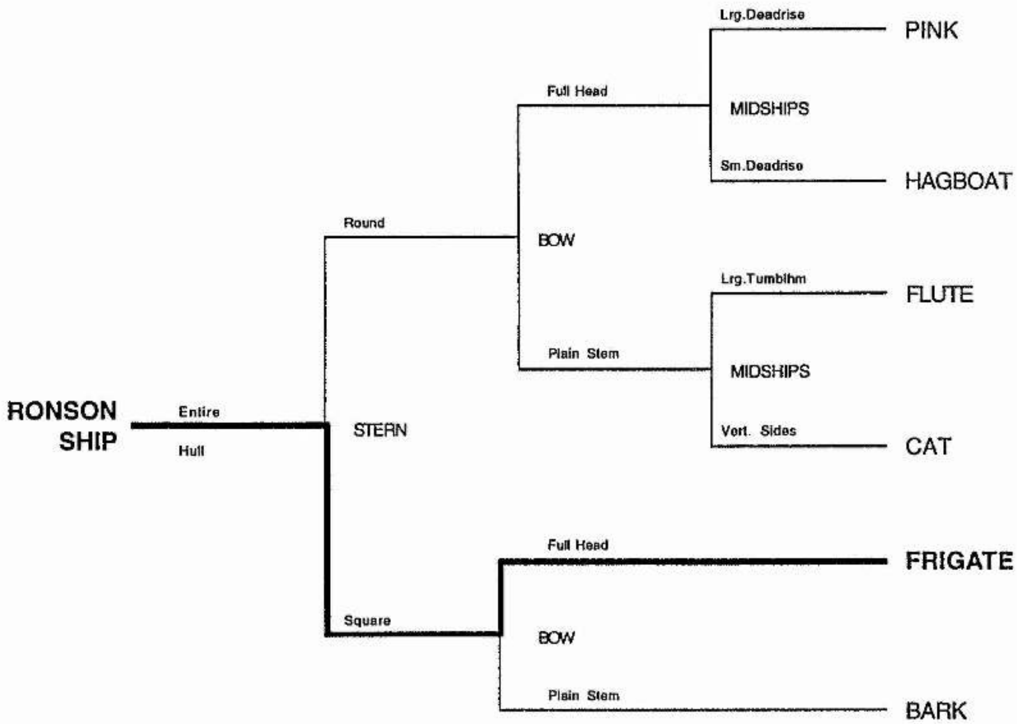


Figure 7.12. Dendrogram method for attempting to define the hull class of the Ronson Ship based on its reconstructed lines plans, using the stern as the initial attribute.

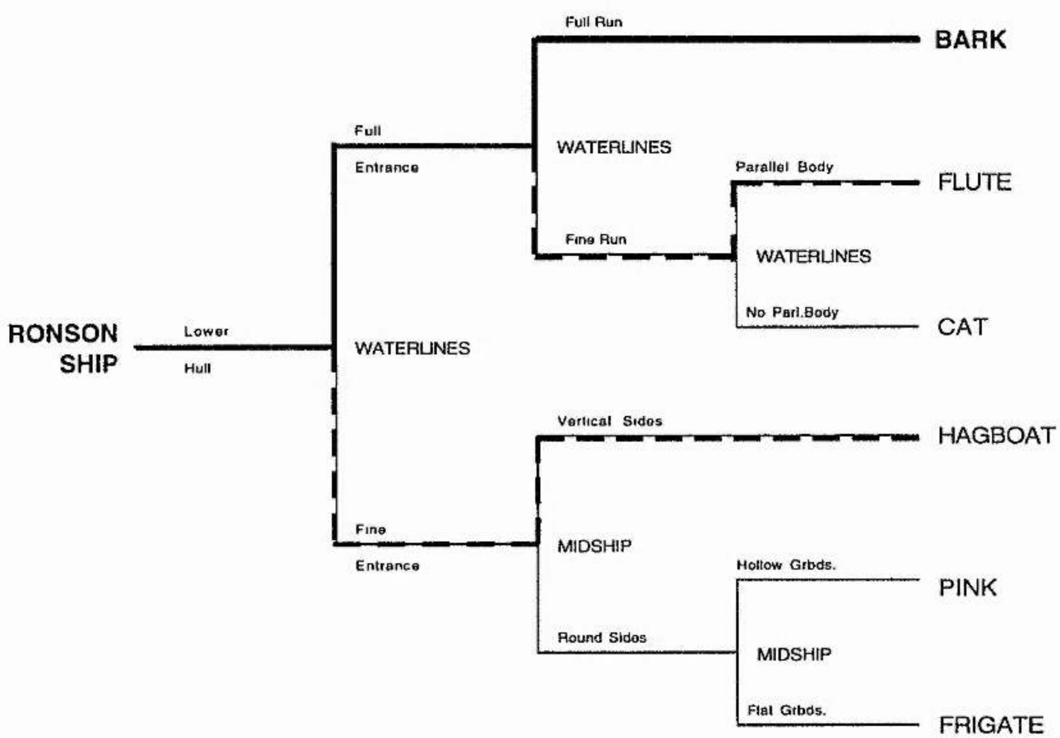
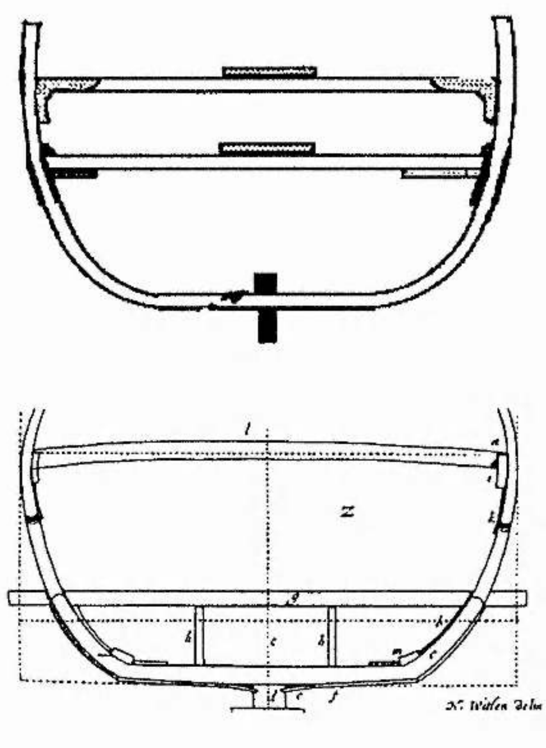


Figure 7.13. Dendrogram method for attempting to define the hull class of the Ronson Ship based on its recorded hull remains, using waterlines as the initial attribute.

led to the development of the more mathematical techniques described in Chapter 2 of this study.

The Ronson Ship is an excellent and well-preserved example of an early English or English-Colonial merchant vessel; its hull shape gives every indication of having been designed with a simple geometric method typical of the late seventeenth century. Although the hull shape is admittedly an unusual blend of design characteristics, Riess provides no support for his contention (1991:179) that "its design may answer Ralph Davis's question…about how British ships became more efficient in the eighteenth century" (the focus of the present study, as described in the Introduction). In fact, the midships section drawn for the Ronson Ship is very typical of the Dutch pattern, rather than the English. Figure 7.14 compares the midships sections for the Ronson Ship and a typical Dutch design, as illustrated in Witsen (1671). This analysis and discussion will be taken up again in the concluding chapter.

Figure 7.14. A comparison of the midships sections of the Ronson Ship (Riess 1987b:22), top, with a typical midships section for a late seventeenth century Dutch vessel, as illustrated in Witsen (1671, as reproduced in Phillips-Birt 1979:152).



Defence

The *Defence*, a 170-ton brig, was built in Beverly, Massachusetts in 1779 to serve as an armed Continental privateer (Wyman 1981a:96). On August 13 of that same year the *Defence* and 43 vessels of the Continental and Massachusetts state navies were forced by British warships to retreat into Penobscot Bay, now part of the state of Maine; the crews had to scuttle their ships. The *Defence*'s remains were located in 1972, initiating a multi-year investigation of the site. Beneath the mud, archaeologists found articulated timbers of the lower hull, and a large cookstove forward, but also discovered that the magazine had apparently exploded, severely damaging the stern (Figure 7.15). A number of interesting and diagnostic artifacts were recovered and the hull remains mapped and documented (Sands 1988:155-159; Switzer 1987:194-198).

The *Defence* was a contemporary of the *Betsy*, and the two vessels shared many similarities: both were classified as brigs, both were approximately 170 tons in size, both were built using British shipbuilding techniques (assuming, with good reason, that the builder of the *Defence* was British-trained or, at least, was still heavily influenced by British methodology); the hulls of both were approximately 50% intact; both lay in just over 20' of water and were imbedded in protective river silt; and the mast stumps were still stepped in both hulls. However, these two brigs were also quite different. While the *Defence* was built as a fast fighting vessel, the *Betsy* was intended to serve out its career as a bulk carrier. As a result, the *Defence* is a much sharper built vessel than the *Betsy*, having a midships deadrise of approximately 25 degrees (*Ibid.*:92)(Figure 7.16), versus *Betsy*'s nearly flat midships floors. The *Defence* was fitted with a large cookstove, since the crew required to man a privateer her size was many times larger than the *Betsy*'s crew, who probably cooked their meals on a small hearth below decks or possibly on the main deck. The *Defence* was armed with sixteen 6-pounders, while the *Betsy* probably was unarmed until fitted with a few small cannon by the Navy Board when it entered the Transport Service. The *Defence* probably looked very much like the artist's reconstruction shown in Figure 7.17, quite different from the *Betsy*'s boxy shape.

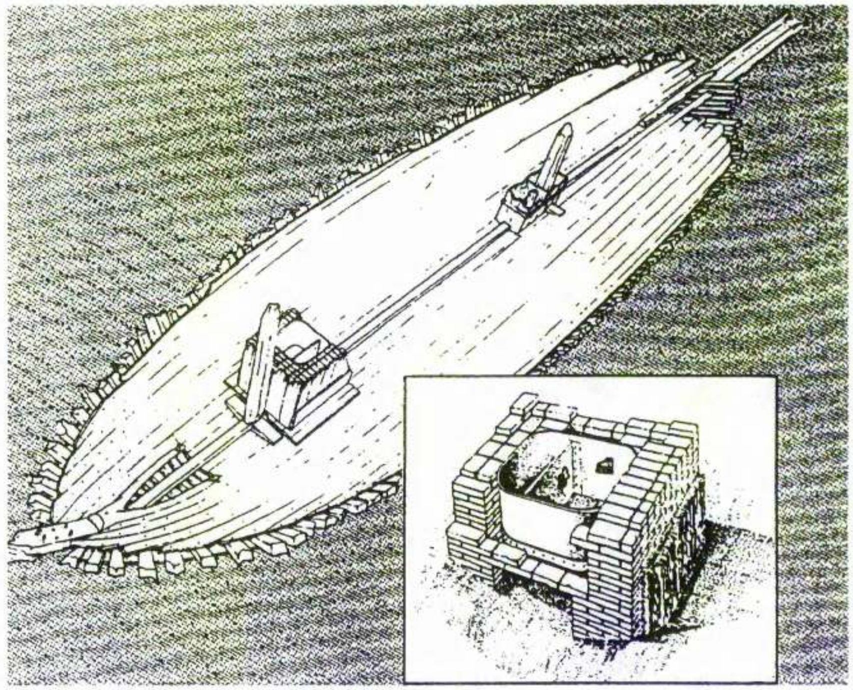
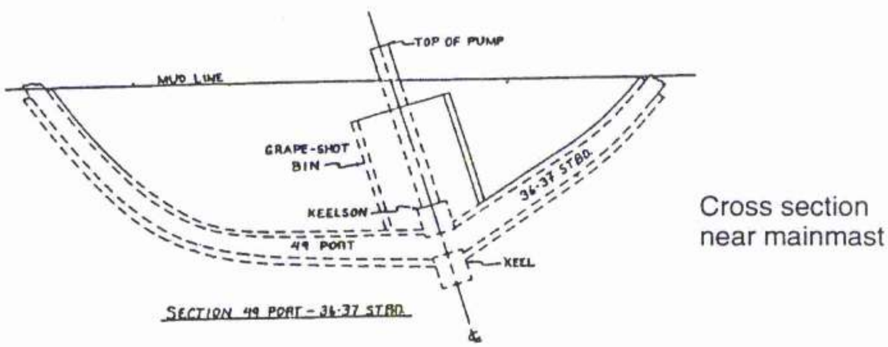


Figure 7.15. The American Privateer Defense (Bass 1988:159)



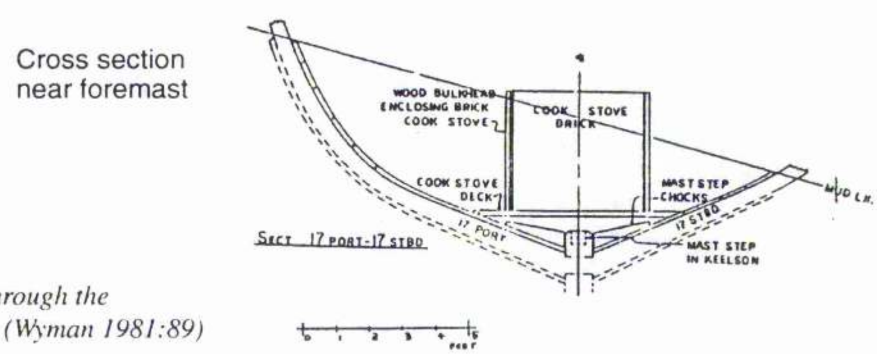


Figure 7.16. Two sections through the American Privateer Defense (Wyman 1981:89)

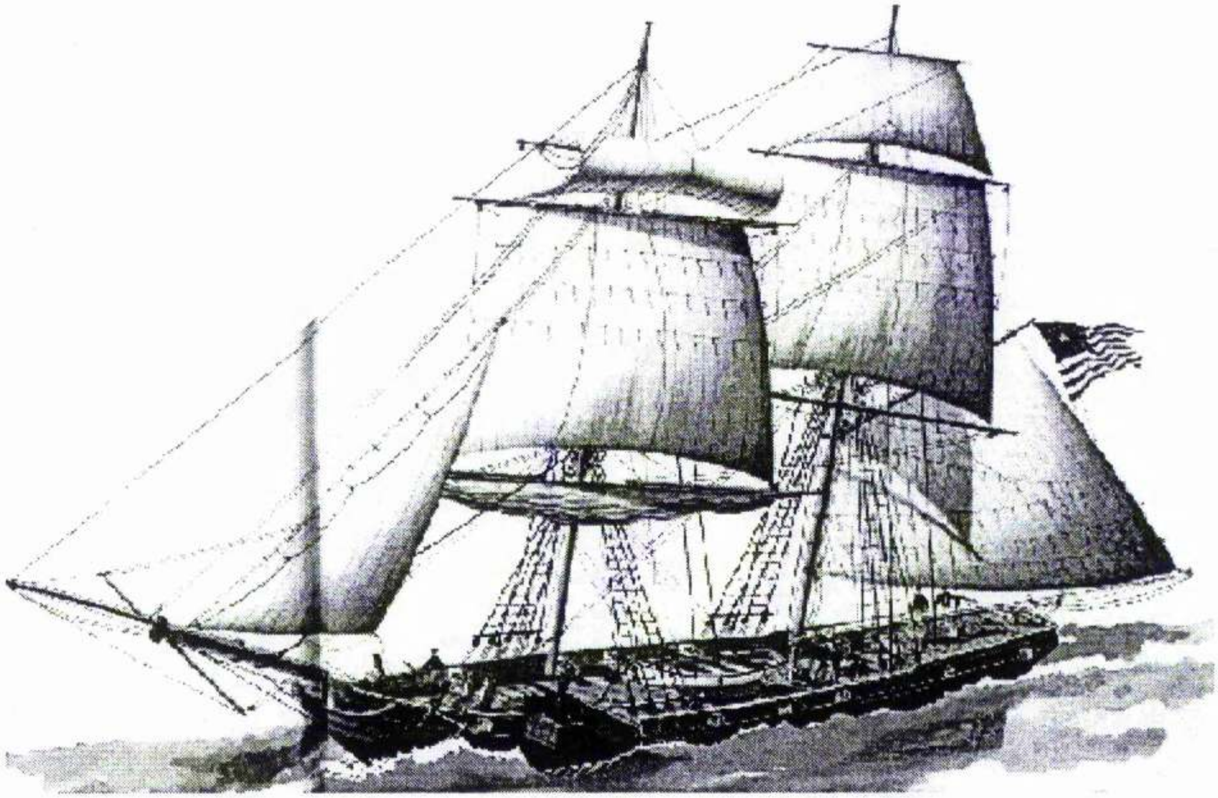


Figure 7.17. Artist's reconstruction of the American Privateer Defence *(Throckmorton 1987:197)*

The *Defence*'s white oak frames were irregular in size and spacing (Figure 7.15) and evidence indicates that not all futtocks were joined to form compound frames. Instead, "mold frames," consisting of floors and futtocks joined by fore-and-aft trunnels were erected on irregularly-spaced centers; the mold frames were spaced as closely as 4'7" near the foremast step and as far apart as 10'8" near the stern. The remaining futtocks had been installed afterwards, 3-6" apart, and fastened only to the planking (Wyman 1981a:86; Wyman 1981b; Wyman 1984:70). The mold frames consisted of large floor timbers fayed to first futtocks and fastened with two trunnels each, one near each floor head and one near each futtock foot. All futtocks met at a simple butt joint. Futtock size varied widely, with sided dimensions ranging from 4-10" and molded dimensions at the heel averaging 8" (Wyman 1984:70). The bow was formed of cant frames; the stern was not preserved far enough aft to determine the framing pattern aft of the last preserved square frames (*Ibid.*). Not all of the ceiling was removed, apparently leaving much of the framing detail unrecorded. Mold frame 43/44, located aft of the midship couple (not identified on Wyman 1981b, but probably frame pair 25/26) has its first futtocks fastened to the aft face of its floor. No information was found on the configuration of the other mold frames.

Wyman (1984:70) reported that the exposed frames "added to the understanding but also the confusion because typical double futtock frames were not being found." Data compiled during the present study offers conclusive evidence that paired-frame, or compound-frame, construction was the exception rather than the rule. It appears that the *Defence* was probably built with nine mold frames, which the present study shows to be fairly typical. The Ronson ship, discussed above, is one of the few shipwrecks supposedly constructed entirely with paired frames. Additional published information on both these vessels is needed for a final analysis and comparison.

OTHER RELEVANT SHIPWRECK SITES

General Carleton, 1777

In 1995, scuba divers found a new wreck approximately one nautical mile off the coast of Poland, north of Gdansk Province, at a depth of 23' and covered by 3-6' of silt. The site, designated W32, was investigated annually by the Polish Maritime Museum during 1995-1997. During the first excavation season, the ship's bell was recovered. The inscription on the bell read "General Carleton of Whitby 1777." The *General Carleton* was a 500-ton merchant ship, built in the British port of Whitby in 1777. On September 27, 1785, as the ship was returning home with a cargo of tar and iron, it was stranded on the Polish coast. The *General Carleton* was a total loss and the entire crew of 25 men drowned.

During the 1996-97 seasons the excavation was a joint project with DEGUWA, the German underwater archaeology society, and sponsored by Seemann Sub, of Germany.

Only the lower parts of the 105-foot-long oak hull survives, along with most of the cargo (Figure 7.18). Tons of iron bar had to be removed from the hull and placed off to the side of the hull. Numerous barrels of tar, comprising part of the cargo, had been crushed, allowing the contents to leak out and create a hard coating over the lower hull. This protective coating preserved many of the objects contained in the ship's bilge. Among the finds is a thermometer; a brass telescope; pieces of clothing; hundreds of shoe buckles, obviously part of the cargo; and kitchen utensils. The remains of one crewman were also found. The largest object salvaged was the 440-pound (200 kg) iron stove. Two large anchors, located on the starboard side of the hull, are to be reburied at the site (Stolpe and Achenbach 1997:50-53).[7]

This study conducted a brief review of *Lloyd's Register of Shipping* for information on the *General Carleton*. The *Register* for 1778 lists the *General Carleton* as a 500-ton ship having a 16-foot draught and a single deck with beams for a lower deck; T. Pyman, master, and "N.Cmpion", owner; built at Whitby in 1777; with listed ports of Riga and London. *Lloyd's Register* for 1782 noted several important changes: beneath the previous ports of Riga and London, "LoTrnspt" had been added; the vessel had been sheathed in 1782, and ten 6-pounder cannon had been added; also W.Hustler had become the new master. This information indicates that the *General Carleton* was leased in 1782 by the Navy Board for employment in the transport service. In all likelihood, it had undergone similar modifications to those given the *Industry* (see the section on the Bermuda merchant vessel, earlier in this chapter): a full lower deck, hull pierced for the new armament, etc. Two years later *Lloyd's* listed the *General Carleton* without armament; the ports were listed as "RigaPh" and the "transport" designation had been removed; W.Hustler was still listed as master. The 1786 *Lloyd's* does not list the *General Carleton*, which supports its reported loss in 1785.

Additional information received from the Polish Maritime Museum (Ossowski 1997)[8] reports that the "N.Cmpion" listed in *Lloyd's* as owner was Mrs. Margaret Campion, a Freeman of the Russia Company that controlled all British trade with the Baltic. Appar-

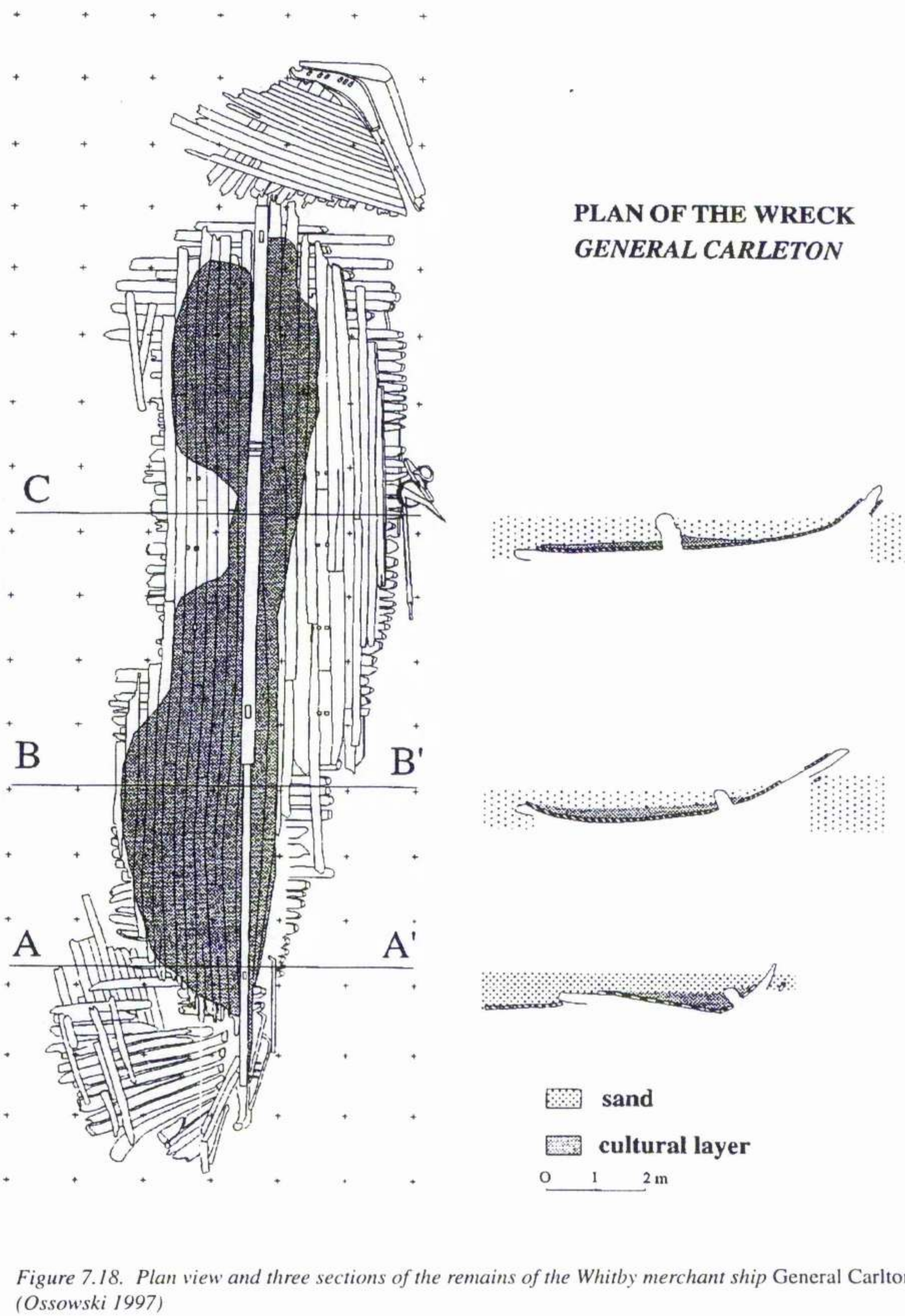


Figure 7.18. Plan view and three sections of the remains of the Whitby merchant ship General Carlton *(Ossowski 1997)*

ently, the *General Carleton* was built in Whitby to carry coal from the Tyne to the Thames, with occasional employment in the brisk Baltic trade (*Ibid.*). A Stockholm port book records that the General Carleton was loaded on August 30, 1785 with 230 heavy lasts). This same book gives the vessel's measurements as: 108' length on lower deck, 30.5' extreme beam, draft of 17.5' and 500 tons (*Ibid.*).

The field work was completed in 1997, and all material from the excavation is being conserved at the Museum's conservation department. Unfortunately, few details of the hull construction have been published and efforts to obtain additional information were not successful. If the hull remains were recorded in detail, this site should yield extremely valuable comparative data on eighteenth-century English merchant vessels.

Yorktown Shipwrecks 44YO89 and 44YO94

These two shipwrecks, described in Chapter 4, appear to be large English merchant vessels (350 and 430 tons, respectively) that were being employed as transports when sunk, probably by scuttling, at Yorktown, Virginia in 1781. As with the Yorktown transport *Betsy* (See Chapter 5), these two hulls seem to be extremely well preserved and, if excavated, would provide extremely valuable comparative data on English merchant vessels. In fact, because of their extraordinary state of preservation, different sizes, known British origin and known date of sinking, shipwrecks YO88, YO89 and YO94 offer the opportunity for a truly unprecedented comparative study of contemporaneous English merchant vessels. The author is currently discussing possibilities for detailed surveys of YO94 and possibly YO89 as well.

Seaton Carew Shipwreck

The Seaton Carew Shipwreck (SCW 96) was located in August, 1996 after it was uncovered on Seaton Beach, on the northeast English coast, by a combination of tides and storms. Fortunately, the site was quickly surveyed by volunteers from the Northern Region Nautical Archaeology Society and Tees Archaeology staff before shifting sands covered the site again in November. The wreck has not reappeared since that time. The site plan gener-

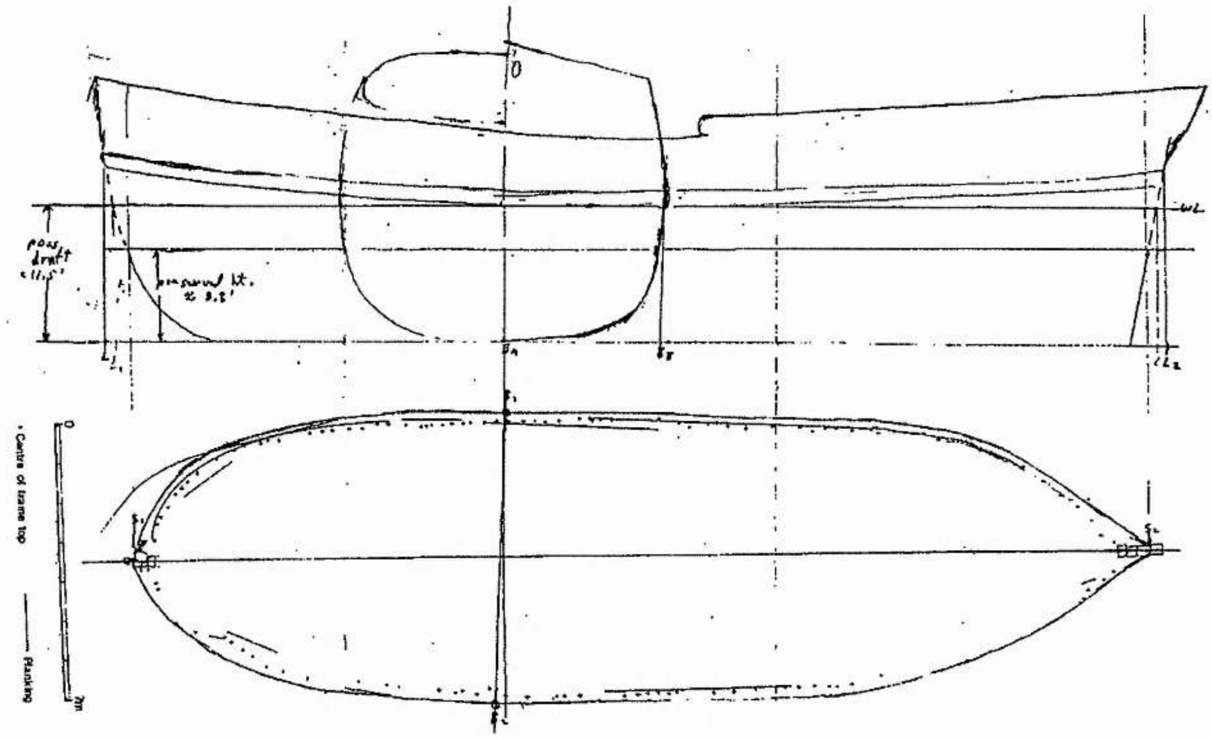


Figure 7.19. Plan view of the Seaton Carew shipwreck, on which the author has sketched a hypothetical hull form (Green 1996; Broadwater 1996)

ated during the survey consists primarily of the locations of the stem- and sternposts, along with a series of points outlining the exposed frame ends (Green 1996). The brief initial site report (*Ibid.*) indicated that the timbers are in good condition and the numeral "VIII' observed on the sternpost verifies that a considerable portion of the hull survives intact. The vessel was estimated to be "a typical North-East collier brig or schooner of between 150 and 250 tons burthen" but since more than 50 vessels are reported wrecked in that area, the Seaton Carew shipwreck has not been identified.

For the present study, the author sketched a possible hull shape, using the survey team's site plan as a guide and making the assumption that the vessel was, indeed, a locally-built collier (Figure 7.19). Using this rough sketch the author derived the following estimated measurements: 86.3' length between perpendiculars, 25.3' extreme breadth and 241 tons burthen. The report's speculation that the vessel represents a locally-built collier is supported by the hull shape. The vessel probably wrecked between the latter half of the eighteenth century and first half of the nineteenth. Little more can be said about this site until cooperative storms or adequate funding permit further investigation; however, there is little doubt that the Seaton Carew shipwreck is a valuable resource that could fill gaps in our data base on English merchant vessels.

ADDITIONAL SHIPWRECKS FROM *CA.* EIGHTEENTH CENTURY

Crosswick's Creek

In March 1986, the remains of two wooden vessels were located and surveyed in New Jersey. Based primarily on architectural features archaeologists concluded that both vessels could date to the third quarter of the eighteenth century, and may have been local-built merchant vessels, possibly fitted out as privateers (Watts and Cox 1986:24-30). "Crosswicks Creek Site 3" is a portion of the extreme lower hull of one of those vessels (Figure 7.20). Site 3

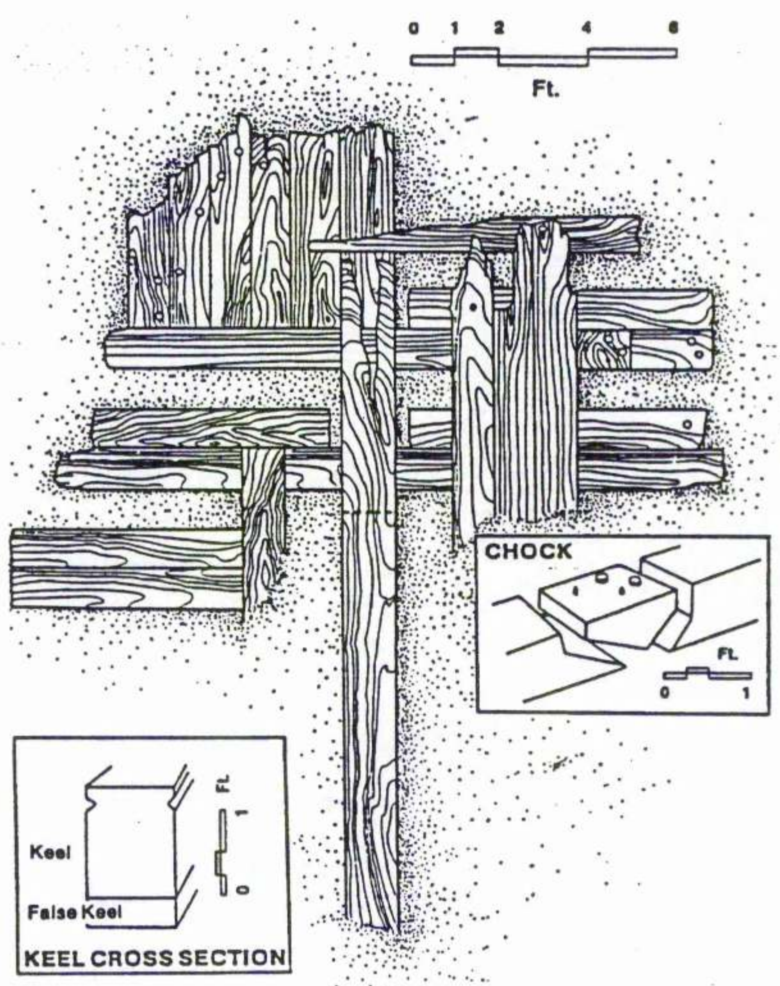


Figure 7.20. Crosswick's Creek Site 3 (Watts & Cox 1986:28).

is of interest because its framing pattern consists of floors with offset first futtocks, similar to the *Betsy*. Also similar to *Betsy* is the presence of a chock scarf between one of the floors and its second futtock. Note that the chock extends the full molded thickness of the futtocks, similar to the chocks of the Slufter collier. All hull timbers appeared to be of oak, and the outer hull was sheathed in wood.

This must have been a vessel of more than 100 tons, as the keel measured 12" sided by 16" molded, the frames 10" sided and 11" molded. Room and space are not given, but a site plan, scale approximate, suggests that it may have been 21" room and 10" space (*Ibid.*:27-28). The minimal remains were not sufficient for predicting the hull shape. This vessel may have been built in the Colonies or in England, since it was sheathed for ocean service. In either case, it is likely that an English-trained shipwright constructed the vessel and, therefore, the hull characteristics are relevant to the present study.

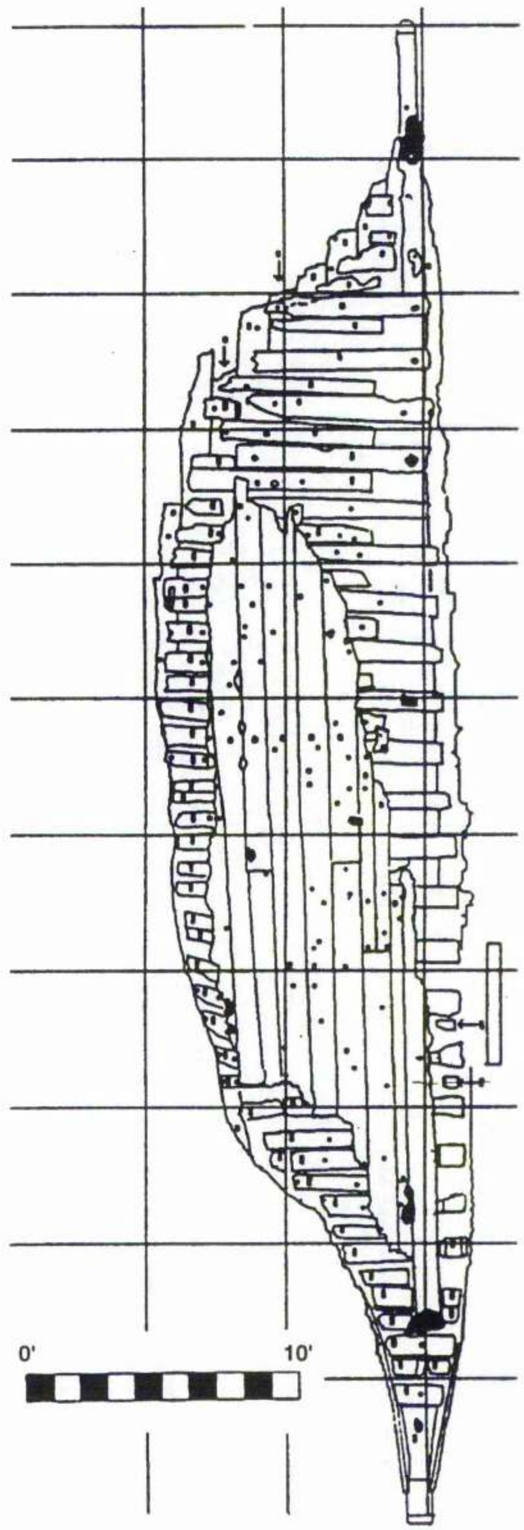


Figure 7.21. Deadman's Island Site Plan (Finegold in Smith 1990:114).

Deadman's Island Site

An archaeological survey in 1988 revealed the well-preserved remains of a wooden vessel eroding from the beach at Deadman's Island, Pensacola Bay, Florida (Figure 7.21). Evidence suggested that the site represented the remains of a British warship from the time of the American War of Independence (Smith 1990:110).

The keel length was recorded as 55.17' with dimensions of 20" molded and 9.5" sided. Floor timbers were spaced 12-14" apart, with sided and molded dimensions of 6-9.5 inches. Some, but not all of the floors were joined to adjacent futtocks with treenails, indicating a pattern of mold frames. Planking thickness was 1.5-1.75" with a width of 8-10 inches (*Ibid*.:114). The two most likely candidates for the identity of this vessel are HMS *Stork* and HMS *Florida*, two Jamaican-built vessels (*Ibid*.:115). This author estimates the tonnage at approximately 100-110 tons. Even if this vessel was built in Jamaica, it may have been built by an English or English-trained shipwright. If additional details become available, they could contribute to the overall theme of this study

Fig Island Vessels 2 and 20

The remains of two vessels documented during archaeological data recovery projects in Savannah Harbor, Georgia in 1996, provide useful comparative data for the present study; both vessels are believed to date to *ca*. 1800. (Gulf Engineers and Consultants, Inc. and Tidewater Atlantic Research, Inc [GEC/TAR] 1996 a and b).

Vessel 2 consists of the lower hull, to the turn of the bilge, of a wooden vessel with an overall length of 67'9" and a maximum preserved beam of 19'7" (Figure 7.22). Based on the site plan and profile drawings (GEC/TAR 1996a:69,109) (Figure 7.23) the present study estimated the tonnage at approximately 200 tons, by the standard eighteenth-century formula. Two mast steps were located in the keelson (*Ibid*.:67) but a third mast could have been stepped higher on the deadwood or on a deck.

The keel and keelson were sided 10.5" and the keelson is square in cross-section (*Ibid*.). The framing consisted of eight bolted assemblies referred to in the report as "master frames" (mold frames) longitudinally through-bolted between floors and futtocks to form rigid, preconstructed frames that would have defined the hull shape.[9] Floors and futtocks in these mold frames were separated with thin spacer boards through which the through-fasteners passed. Between the mold frames were intermediate single frames, with all futtocks joined with simple butt scarfs (*Ibid.*:78). Throughout the hull, all frames consisted of floors with their first futtocks set forward of them (*Ibid.*:82). Heels of all first futtocks are situated over the keel, but the first futtocks do not meet, leaving a space between their heels. The bow was formed of radial cant frames; however, the stern was shaped by relatively large half frames beveled on their outer surfaces to the proper hull shape (*Ibid.*:78).

Based on construction features and the variety of wood types used for hull components, the investigators speculated that the vessel was built in New England, the Canadian Maritimes or possibly on the Great Lakes, and it was estimated to date to the late eighteenth or early nineteenth century (*Ibid.*:113).

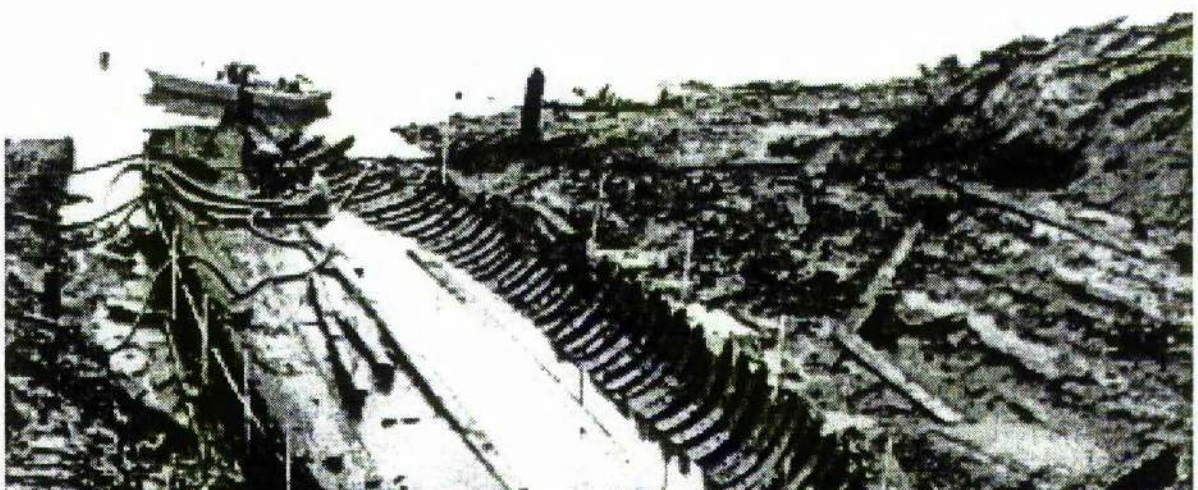


Figure 7.22. Fig Island Wreck #2 during excavation (GEC/TAR 1996a:63).

Vessel 20 is somewhat similar to Vessel 2 in size and construction, consisting of the lower hull of a wooden vessel, with a portion of the stern missing (Figure 7.24). The remains have an overall preserved length of 77'4" and a preserved beam of 21'4" with an estimated original length between perpendiculars of at least 85 feet (GEC/TAR 1996b:86). The hull was badly flattened and distorted, including serious hogging, at least two breaks in the keel and a missing stern (*Ibid.*:49). As was the case with Vessel #2, this hull was formed of mold frames (ten were preserved), with filler frames added later in the construction process; the bow was composed of cant frames with fillers as necessary, as can be seen in Figure 7.24 (*Ibid.*). The framing followed the conventional pattern of having the first futtocks forward of their associated floors in frames forward of the midships bend, and aft of their floors aft of the midships bend (*Ibid.*:56).

In the conclusion, the report states that "the use of evenly spaced master frames was indicative of a technique known as whole moulding" (*Ibid.*). However, the term "whole mo[u]lding" refers to the method of lofting the frame shapes and was, in fact, the only lofting method in which all frames of a vessel were normally pre-formed.[10] The present study provides ample evidence that a vast majority of eighteenth-century vessels were constructed by the method of erecting fully-formed "mold" frames at intervals along the keel, then using battens and planking to complete the hull form sufficiently for the remaining "filling frames" to be added. The hull was too distorted to permit an accurate evaluation of the design and lofting methods employed in its construction.

The use of a variety of wood, including white, red and live oak, suggests a possible Colonial American origin (*Ibid.*:56). The report speculates that the vessel was probably a ship or bark (*Ibid.*:80). Based upon the report's estimate of original keel length, this author computed an approximate size of 250 tons burthen.

Therefore, Vessels 2 and 20 both appear to have been Colonial-built ships or barks of approximately 200-250 tons burthen. Their estimated late-eighteenth century dates and English-American origins make both vessels very relevant to the present study. Unfortu-

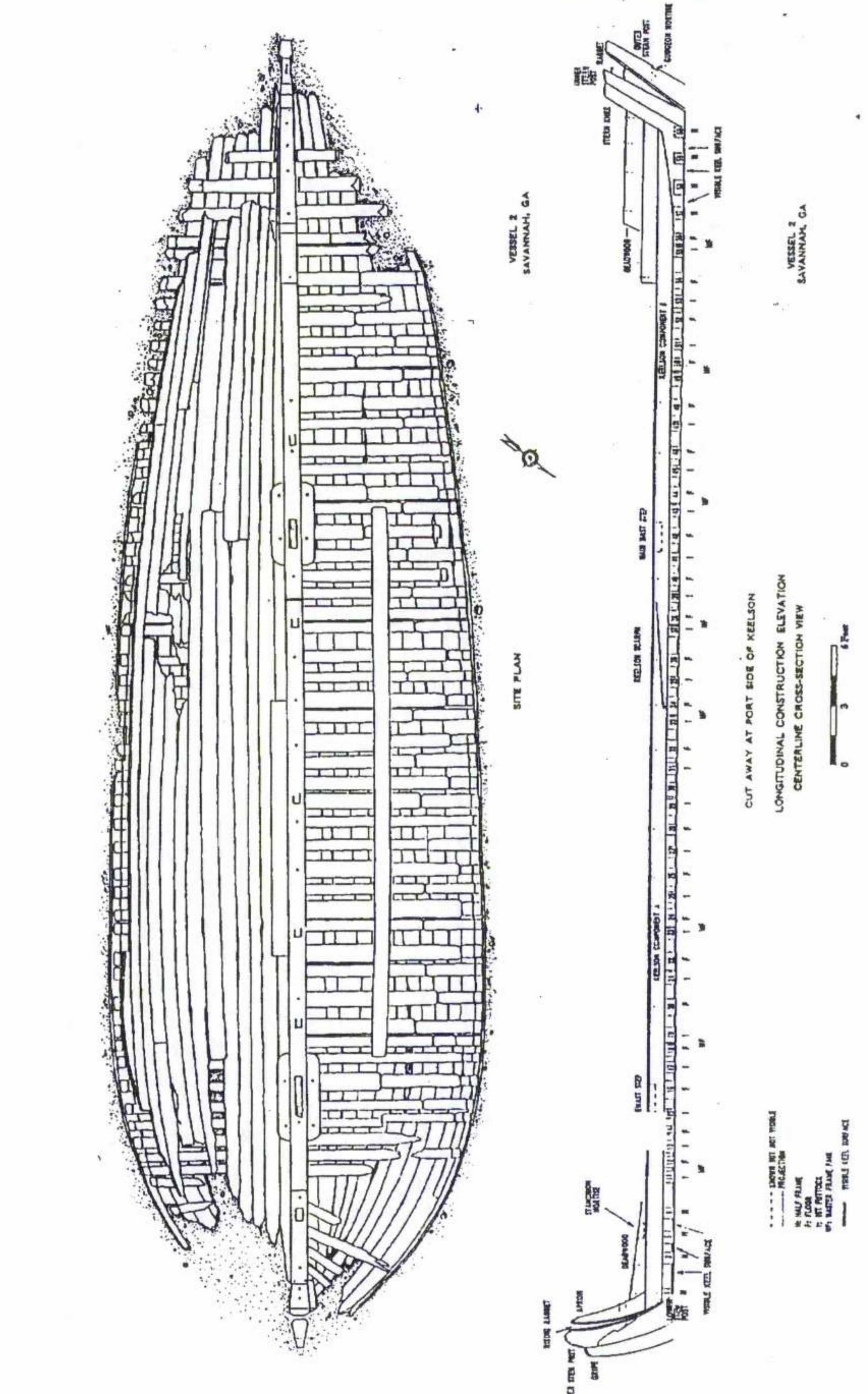


Figure 7.23. Fig Island Wreck #2: Site Plan and Profile (GEC/TAR 1996a:65,69).

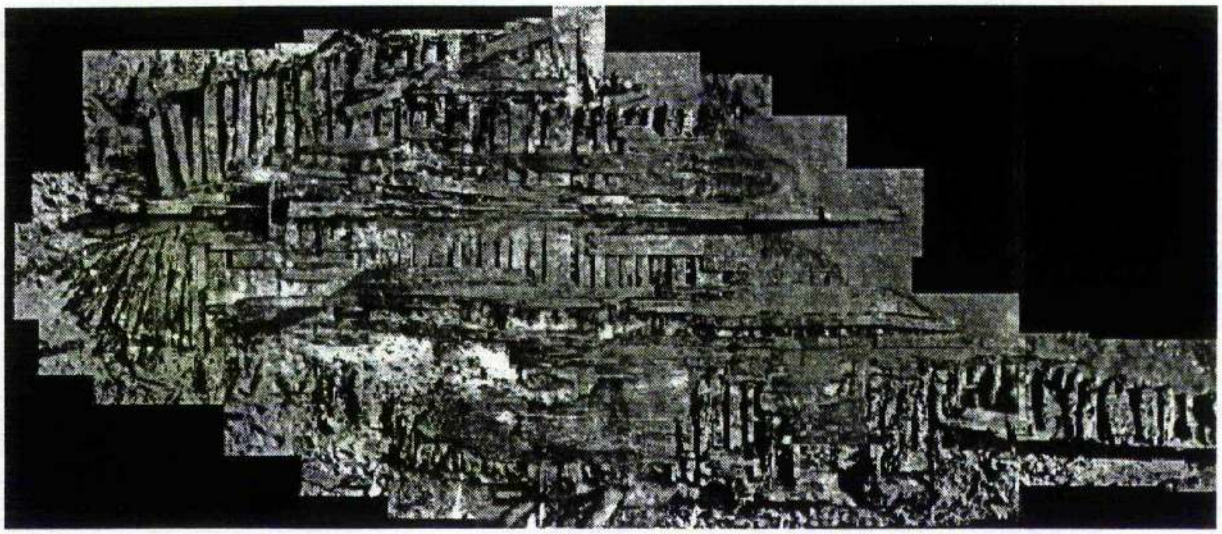


Figure 7.24. Fig Island Wreck #20: Photomosaic Site Plan and Profile (GEC/TAR 1996b:45).

nately, neither was sufficiently well preserved to permit provisional hull lines to be developed.

Old Fields Beach Shipwreck

In April, 1987 the author received a report that a storm had uncovered a shipwreck on the beach approximately one mile south of the Maryland-Virginia border, in the Assateague Island National Seashore (Figure 7.25). The author and John William Morris III volunteered to assist the staff of the National Fish and Wildlife Service in surveying

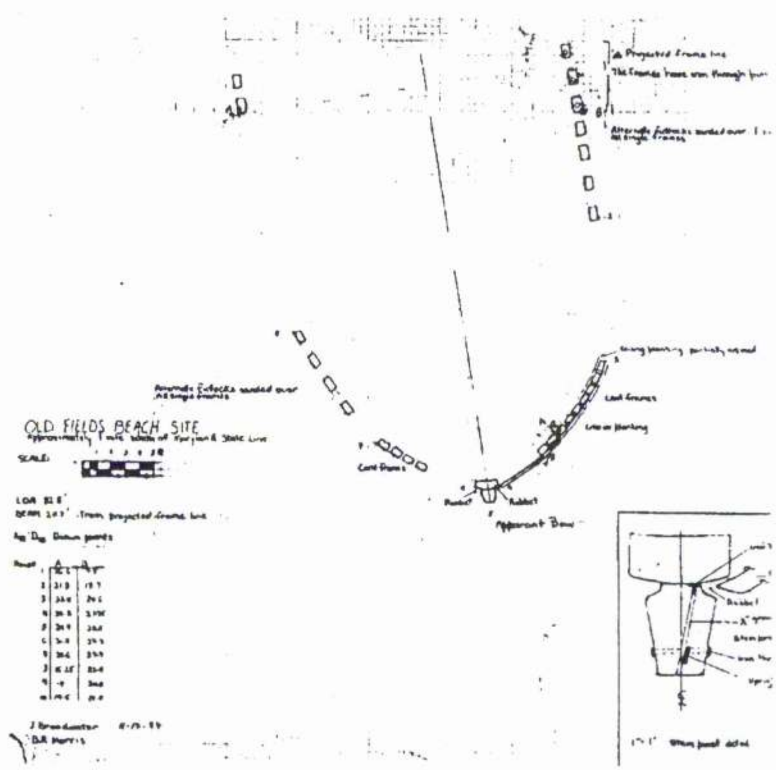


Figure 7.25. Plan view of the Old Fields Beach Shipwreck, Virginia (Broadwater and Morris 1987).

the vessel. A severe northeast storm had eroded a section of beach, cutting away approximately half of a small sand dune and revealing the posts and frame tops of a wooden shipwreck. As shown in Figure 7.25, the wreck was nearly completely covered by the time the survey team arrived, only days after the hull was exposed. However, enough data were recorded to convince the author that the wreck was a merchant vessel, probably dating to the late eighteenth or early nineteenth century. The hull is preserved to a level just above the waterline, based on the presence on the port side of preventer bolts and plates from the main chains. The wreck has been completely covered since this initial survey, thus preventing further investigation.

ADDITIONAL SHIPWRECKS FOR COMPARISON

Amsterdam: The Dutch East India Company ship *Amsterdam*, built in 1748, lies in the surf near Hastings, England, and is in a remarkably well-preserved condition (Bass 1972:251). However, its Dutch origin and large size make the *Amsterdam* unsuitable for this study; additionally, excavation has not progressed deep enough to provide a detailed description of hull construction.

Dartmouth: The remains of the fifth-rate warship HMS *Dartmouth*, wrecked off Mull, Scotland, in 1690 has been well documented and published (Martin 1978:29-58). Even though it is a warship, the *Dartmouth* offers useful comparative data on the construction of English vessels at the beginning of the period of interest of this study. HMS *Dartmouth* was originally built in 1655, then underwent a major rebuild in 1678 (*Ibid.*:31). The extent of the overhaul, which included the fitting of a new keel, is well documented, as are two succeeding surveys, all providing extensive technical information on the vessel's construction (*Ibid.*). The main structural complex (Figure 7.26) consisted of a sizeable portion of the hull; the remains were mapped *in situ* and a large portion raised for further study (*Ibid.*: 41-42).

The details of construction will not be repeated here, but the framing will be briefly described, as it is of particular interest. All preserved frames were of oak, and appeared to have been set on one-foot centers (Figures 7.26 and 7.27). This produced a very tight frame spacing, since the frames averaged 10" sided by 8" molded. Futtocks were joined by chocks that varied considerably in size, but all of which penetrated the full depth of the futtocks (Figure 7.28), similar to those of the Slufter Wreck, described above. This method of "chock scarfs" was formerly though to have been introduced by the Admiralty in 1714 (Longridge 1955:19). The floors and futtocks, although having the appearance of standard paired frames, were found to contain no lateral fasteners and, as stated in the report, must:

> depend for mutual integrity on connection via the strakes and ceiling. They could not, therefore, have been pre-erected, and the hull must have been built by setting up and planking the keel and floors, adding futtocks, chocks and further planking as appropriate.

Although such construction is not unknown, it must be questioned if an English warship would have been so built at such a late date. Was the vessel, indeed, constructed with no

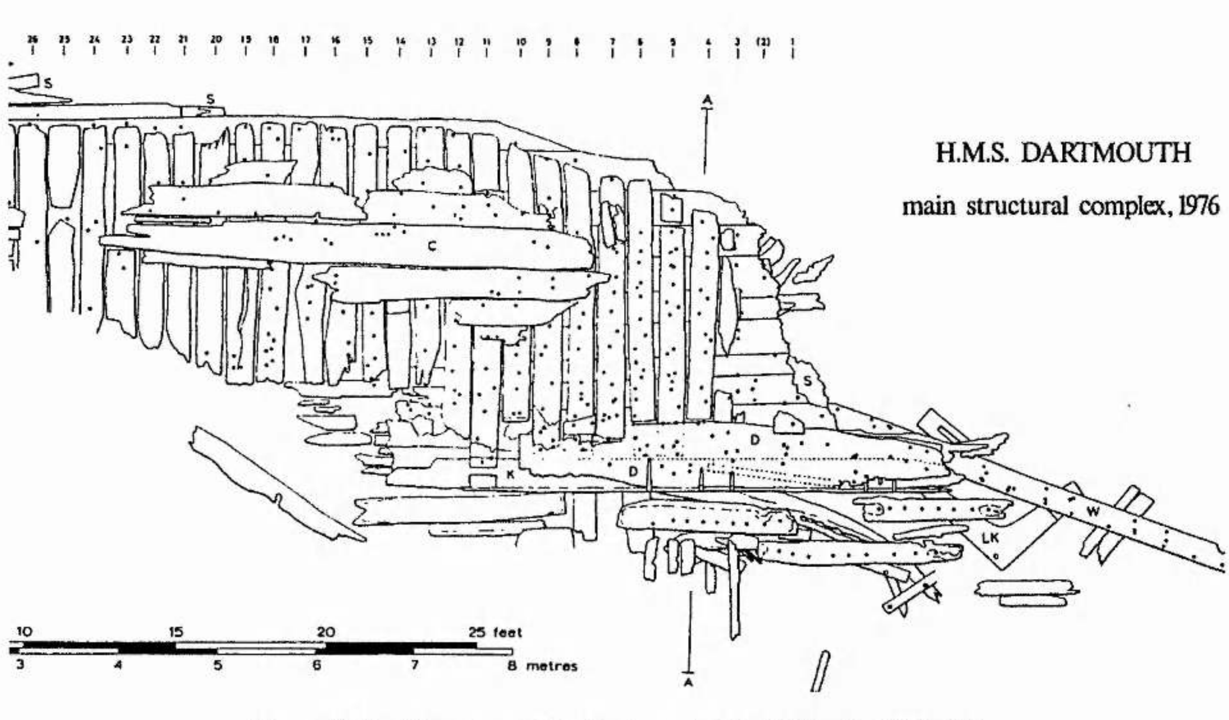


Figure 7.26. Plan view of the Dartmouth, *Mull (Martin 1978:40).*

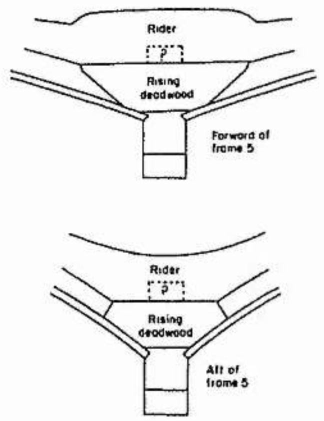


Figure 7.27. Two sections through the remains of the Dartmouth, *Mull (Martin 1978:44).*

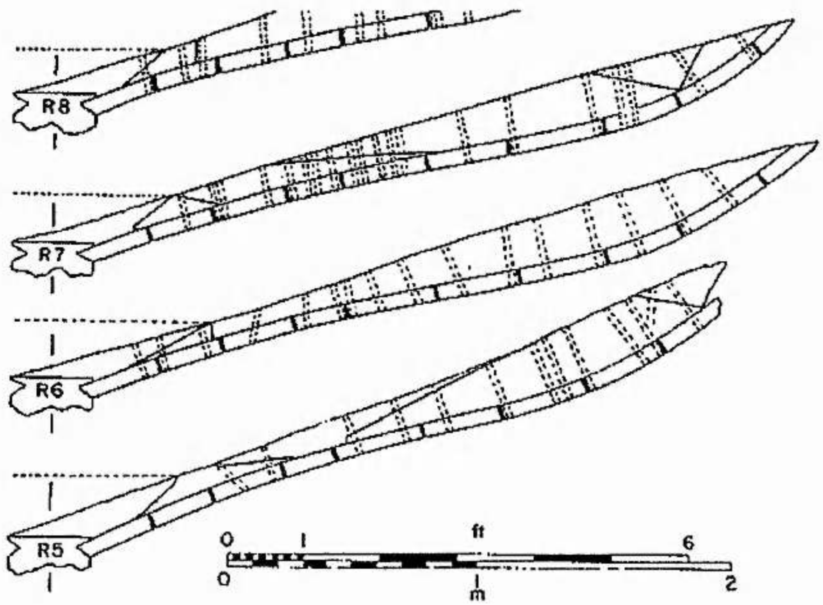


Figure 7.28. Sections through the Dartmouth*'s frames, showing chocks (Martin 1978:45).*

pre-erected (mold) frames, or could this configuration of disarticulated futtocks have resulted from the major overhaul, where it might have been necessary to replace frames in an unconventional manner. However, Martin (1978:55-57) appended the Admiralty report of the 1678 refit, and that report contains no mention of massive replacement of frames. In fact, the mention of frame replacement is remarkable for its total absence! In spite of complete replacement of the keel, post, inner post, head, gripe, rudder and other major components, only a few planks and no floors or futtocks are mentioned in the refit (*Ibid*.).

El Nuevo Constante: This shipwreck, identified as the remains of *El Nuevo Constante*, began life as an English-built merchant ship, the *Duke of York*, 470 tons. In 1764, it was purchased by a Cadiz mercantile family, eventually joining the 1766 Spanish fleet bound from Vera Cruz to Spain. On September 5 of that year, the *Constante* wrecked

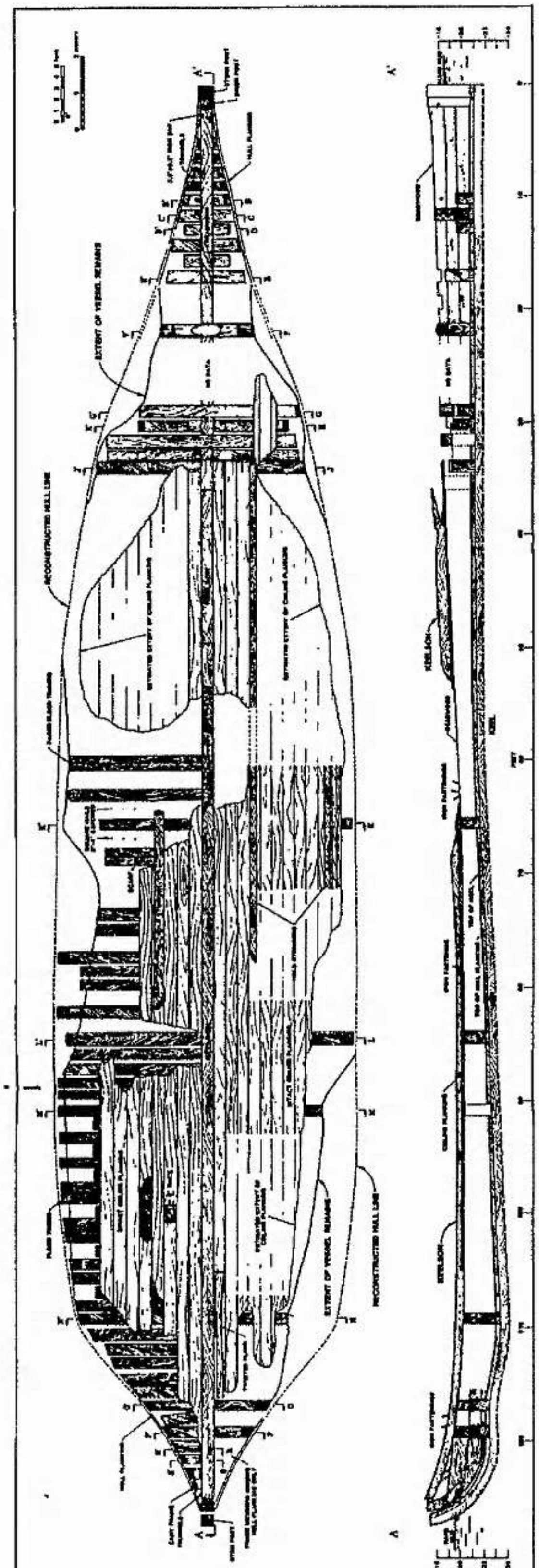


Figure 7.29. Plan view of the hull of El Nuevo Constante *(Pearson 1981:21).*

off the coast of what is now the state of Louisiana; much of the cargo and equipment was salvaged, but the vessel was a total loss. The wreck was located in 1980 and archaeological excavations were conducted (Pearson 1981:3-12).

Only the lowest hull timbers survived, but those minimal remains provided significant information on the vessel's construction (Figure 7.29). The floor timbers averaged 11-13" in sided dimension, and their molded dimensions varied widely, depending upon their location in the hull. The three cross-sections shown in Figure 7.30 illustrate very different types of framing. Section P, very near the bow, shows a square floor (there were no cant frames) with very deep chocks beneath it. Section K, near midships, illustrates a very long floor that extends all the way to the turns of the bilge (unless the floor/futtock scarfs were not identified in the poor visibility). Even in this area, thin chocks are used to provide some rise of floor for the planking. Section E shows twohalf-frames (mis-identified as floors) fastened to three rising wood timbers. The outer planking was reported to be 4" thick, fastened with

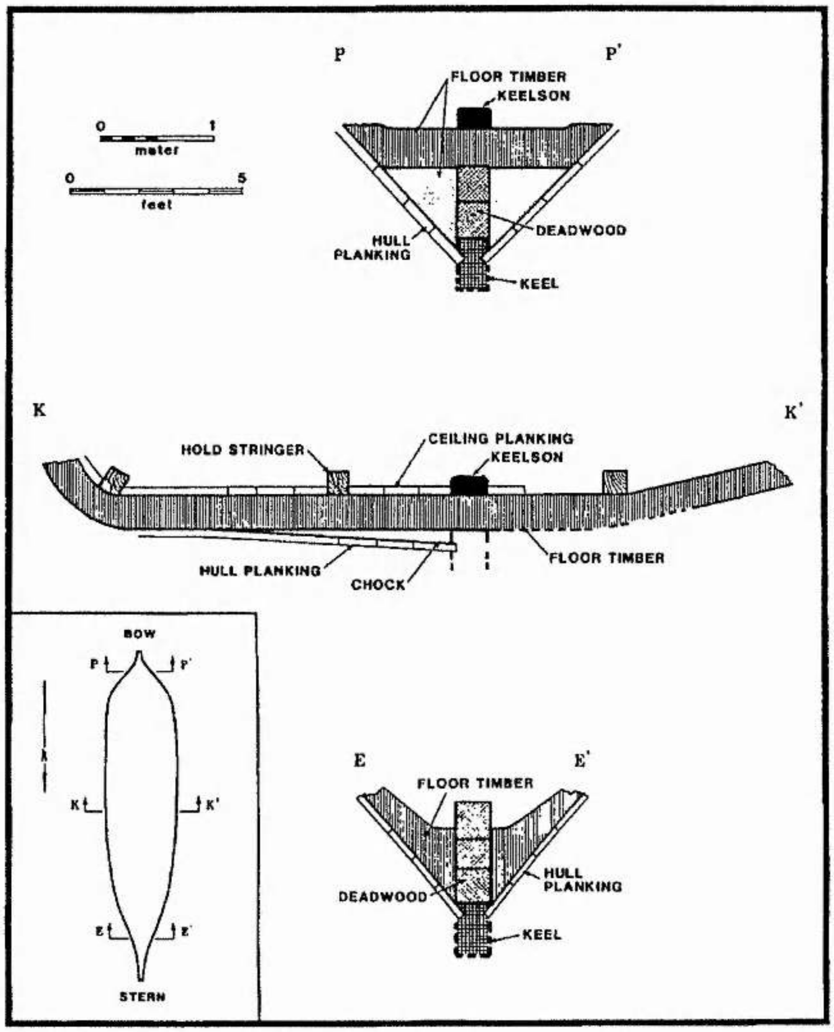


Figure 7.30. Three sections through the hull of El Nuevo Constante *(Pearson 1981:17).*

wooden treenails of 1.75" diameter.[11] A sample of 1" thick wood sheathing was found attached to the hull near the stern (*Ibid.*:16-20).

The hull was not completely documented, so the full extent of the construction is not known. However, based on the site plan, it appears that many of the frames may have been single, and a pattern of mold frames probably existed. Many of the first futtocks were set off approximately a foot from the keel (*Ibid.*) The overall dimensions of the hull remains, plus the recovered artifacts, appear to confirm the identity.

Hamilton **and** ***Scourge***: The sunken remains of the *Hamilton* and *Scourge*, two American topsail schooners from the War of 1812, could someday provide valuable comparative information. The *Hamilton*, a 76-ton merchant schooner originally named *Diana*, was built in Oswego, New York in 1809, by a shipwright from the Baltic; however, the shipyard was owned by a Scot from near Glasgow, so it can be assumed that the vessel would have British characteristics (Cain 1983:40). The *Scourge* was built just to the north, in Niagra, Canada in 1811, as the schooner *Lord Nelson* (Figure 7.31). Although built by a

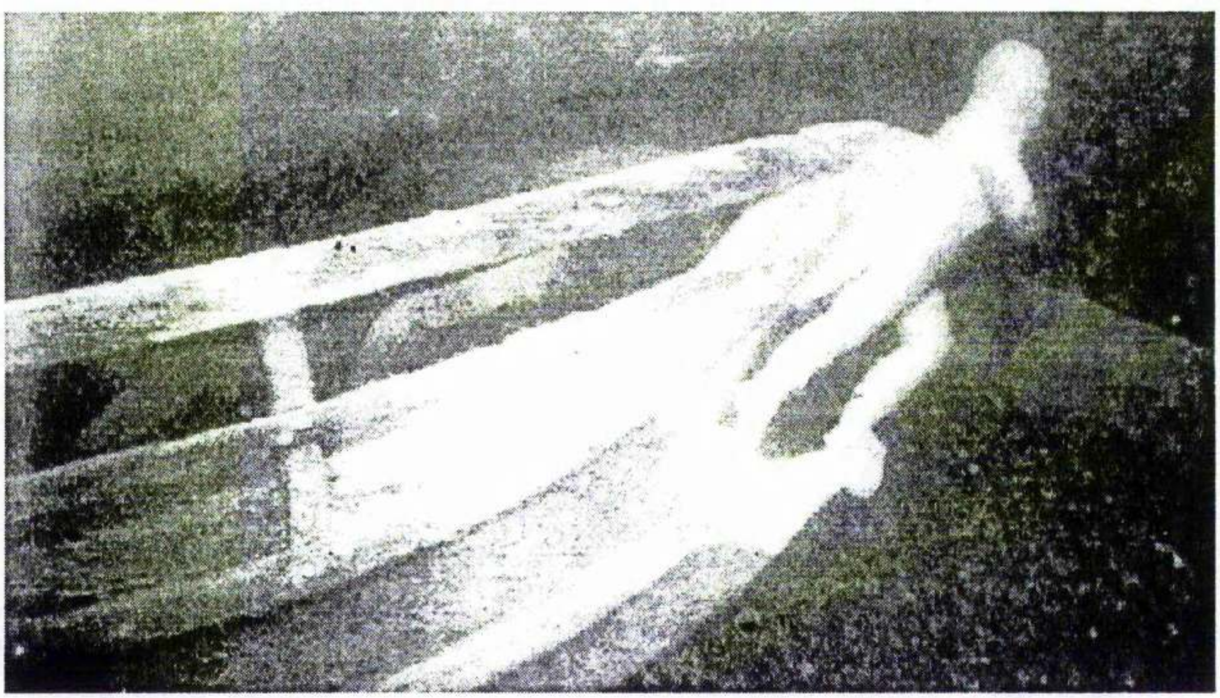


Figure 7.31. The figurehead of the Scourge *(ex* Lord Nelson*) (Bass 1988:181).*

Canadian shipwright, this builder, too, probably had British training (*Ibid*.:36). In 1813 both vessels sank in Lake Ontario, near the Canadian town of Hamilton, during a severe line squall (*Ibid*.:99-110). Both wrecks were located in 1975 using a side-scan sonar (*Ibid*.:131); since then two expeditions have produced dramatic photographs of the wrecks using remotely-operated vehicles (*Ibid*.:132; Cassavoy and Crissman 1988:176). The cold, anoxic environment at the 300-foot depth in which the wrecks lie has preserved them in an incredibly intact state (Figures 7.31 and 7.32), but has also prevented an intensive survey that could provide detailed data on the hull form and construction characteristics of the schooners. In 1990 both wrecks were extensively mapped by a team headed by oceanographer Robert Ballard and archaeologist Margaret Rule. Hours of video were recorded and a remotely-operated vehicle (ROV) was used to make measurements that were automatically fed to a computer for mapping; however, the results from that expedition have not been published. In any case, the vessels would be useful for the present study only as secondary comparative sites.

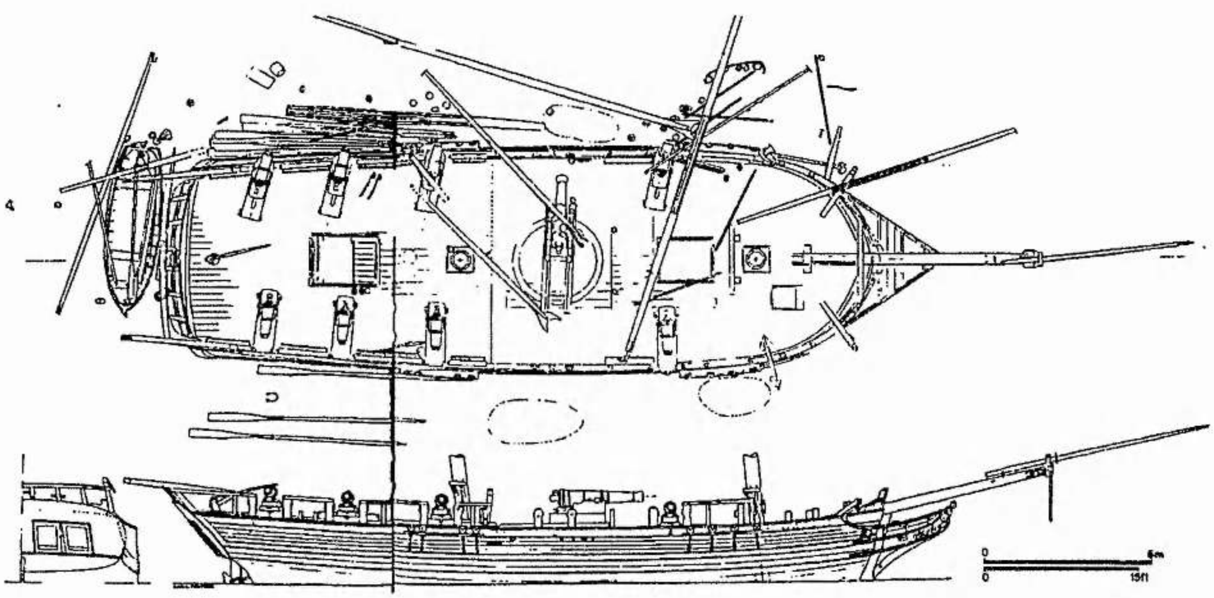


Figure 7.32. Plan and profile drawings of the Hamilton *(ex* Diana*) as found on the seabed (I. Morgan in Bass 1988:174-175).*

Kraken: This small foreign vessel is mentioned because of the very unique configuration of its frames. A revenue cutter, the *Kraken*, found and recorded in Kalmar Harbor, Sweden, had all of the first futtocks on the starboard side aft of the floor. On the port side, however, all of the first futtocks were forward of the floors. The *Kraken* was lost in 1651. Another interesting feature of the *Kraken* was the complete lack of transverse longitudinal fasteners between the floors and first futtocks on either side. The first futtocks were also lapped about 1'6" up from the centerline. This technique was extremely common and continued in the Royal Navy into the first half of the eighteenth century. In merchant vessels this practice continued well into the nineteenth century (Baker 1955:24-25).

San José: The *San José de las Animas* sank off the coast of the state of Florida along with many other ships from the New Spain fleet of 1733. The vessel was originally an English-built vessel of $326^1/_2$ tons and is, therefore, relevant to this study. The

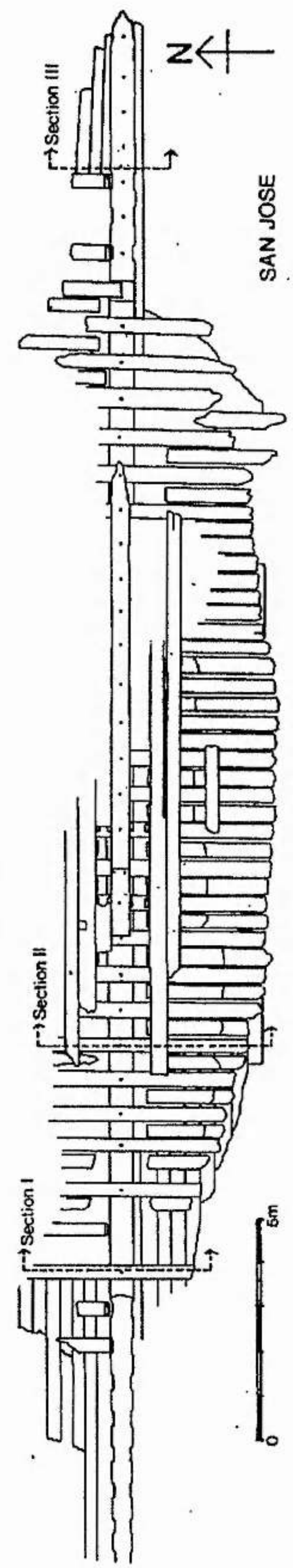


Figure 7.33. Plan view of the hull remains of the San José *(Bass 1988:102).*

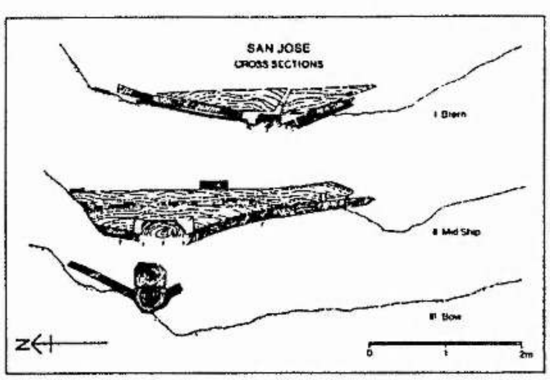


Figure 7.34. Three sections of the hull remains of the San José *(Bass 1988:102).*

few remaining hull timbers have been only partially recorded; however, a site plan was drawn, based on a photomosaic, and this has provided very helpful details on hull construction (Figure 7.33). The plan shows offset first futtocks, some set well off the centerline, and several frames were drawn (Figure 7.34) but no further information is yet available on the framing pattern (Bass 1988:102).

EXTANT VESSELS OR VESSEL REMAINS

Brown's Ferry Vessel: The Brown's Ferry Vessel, a small vessel laden with bricks, was recovered from the aptly-named Black River in South Carolina in 1976 (Figure 7.35). Its capacity was estimated at about 25 tons (Steffy 1988:120). Later analysis and recon-

Figure 7.35. The Brown's Ferry Vessel (right) being raised from the Black River, South Carolina in 1976 (Bass 1988:121).

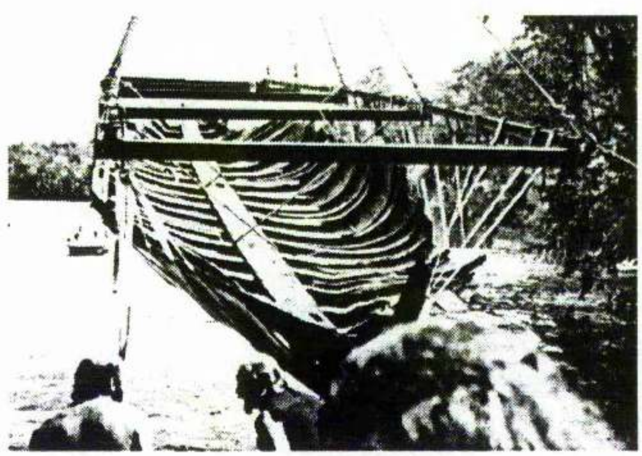
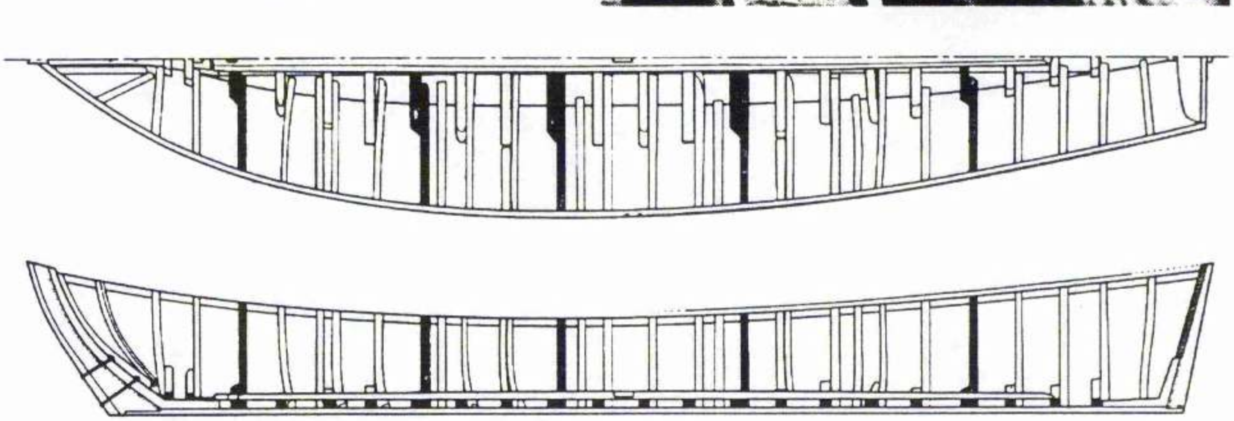


Figure 7.36. Plan and profile views of the Brown's Ferry Vessel, showing framing and mold frames (Hocker 1992:22).



struction determined that the hull was 50'3" long on deck, had a molded breadth of 13'7" and a depth of only about 4' amidships. Artifacts associated with the hull indicate a mid-eighteenth century date (Hocker 1992:20-21). This hull can not be directly compared with seagoing English vessels, since it was a flat-bottomed, locally-built coastal vessel (*Ibid.*); however, it is one of the earliest preserved hulls in North America and dates to the period of interest. The hull was formed from a three-plank spine on which 20 frames were erected, five of which were joined to form "key" or mold frames (*Ibid.*:22-23) (Figure 7.36). Each frame consisted of a roughly-symmetrical floor timber and a long futtock on either side that forms the turn of the bilge and extends to the rail. Except for the forwardmost frame, all futtocks are set behind their respective floors (*Ibid.*:22). The Brown's Ferry Vessel has been extensively studied and documented, providing valuable information on the construction of small coastal vessels.

USS *Constitution* and USS *Constellation*: These two vessels were built in 1797 by the newly-formed United States. The 44-gun *Constitution* remains in commission to this day and, in 1997, on the bicentennial of its launch, *Constitution* sailed under its own power for the first time in more than a century. Because of extensive repairs and rebuilds over the years, the authenticity of much of the fabric of both vessels, particularly that of the *Constellation*, is in question. In any event, neither ship is particularly relevant to the present study since both were American-built warships.

***Eagle*:** The War of 1812 left behind a surprisingly large number of sailing and rowing craft, many of which have been preserved in Lakes Champlain and George (Cassavoy and Crissman 1988:182-186). A survey of southern Lake Champlain in 1981 located the *Eagle* and two other warships. The *Eagle* was found to be particularly well preserved, and a two-year study documented the site (*Ibid.*:185). The *Eagle* had been built in a remarkable 19 days, and the hull exhibited evidence of that hasty construction; yet, in general, it was built with heavy, closely-spaced frames that were well-fastened (Figure 7.37). The hull was 117'3" in length between perpendiculars, 34'9" in molded beam, with an extremely shallow depth of 7'3" at the midship frame, this latter a limitation imposed because of the shoal lake

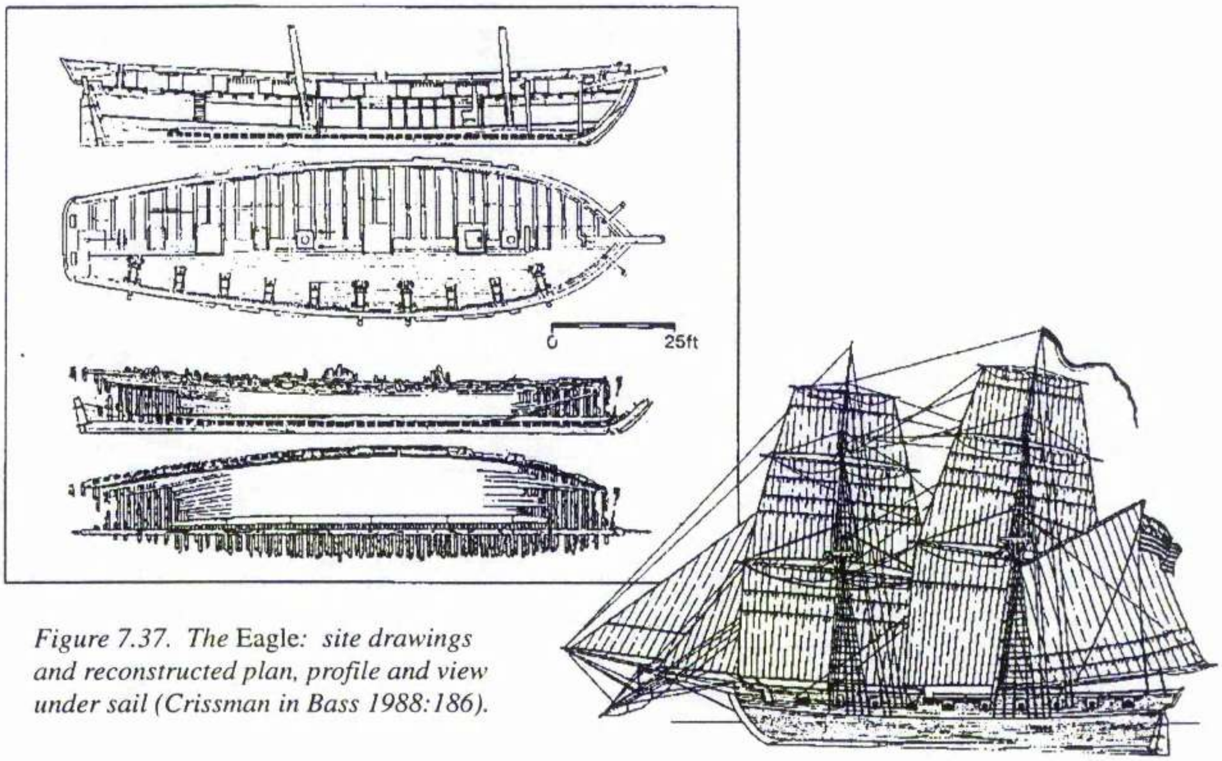


Figure 7.37. The Eagle*: site drawings and reconstructed plan, profile and view under sail (Crissman in Bass 1988:186).*

conditions (Ibid.:185-186). The *Eagle* was well documented, but relates only remotely to the vessels of interest in the current study.

***Lutina* (?)**: During a survey in 1962, a well-preserved vessel was located in Oostelijk Flevoland, The Netherlands, an area of the Zuiderzee formerly covered by water. The site was excavated in 1976 and is believed to be the *Lutina*, sunk in 1888 (Reinders 1982:70). The hull measured 65'7" length by 14'9" in beam. The exact type of vessel is not known and the identity is only speculative (*Ibid*.:67-71). The vessel is included here because the bow construction, strikingly unusual by English standards, bears remarkable similarities to the *Betsy*'s horizontal "apron chocks" (See Chapter 5). As shown in the photograph and profile drawing, Figure 7.38, the bow is so bluff that the builder simply continued inserting floor timbers, following the inner curve of the stem and decreasing the length of the "bow floors" as appropriate. The remaining space was filled by bringing the line of futtocks around the curve of the bow to form cant frames. Although the horizontal bow timbers of this hull are

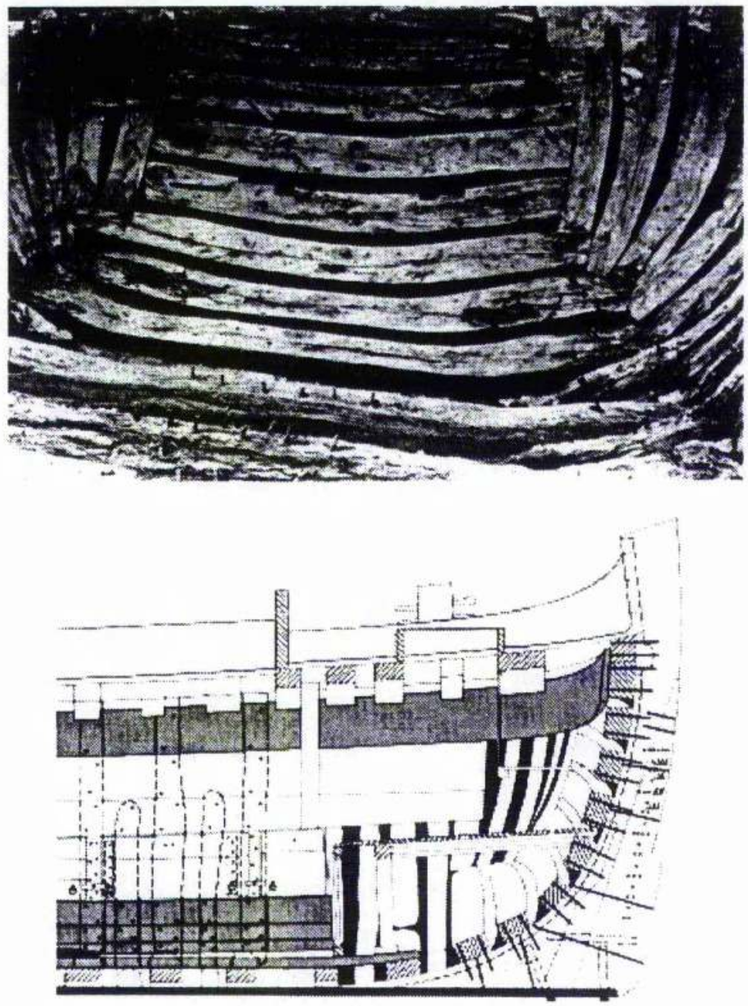


Figure 7.38. Photograph and profile drawing of the bow of a vessel thought to be the Dutch cargo vessel Lutina, *showing the massive transverse bow timbers (flevobericht nr. 292:16).*

much longer than those of the *Betsy*, the configuration suggests that it may well have been such a Dutch-built vessel that inspired the *Betsy*'s unusual bow and stern chocks. A review of Dutch documents and draughts from the eighteenth century also revealed the use of similar horizontal framing in the bows of oceangoing vessels during that period, making it likely that the construction features would have been seen in English ports.

Philadelphia: The Continental gunboat *Philadelphia* was located in Lake Champlain in 1935, its mast still stepped and cannon on their carriages. This flat-bottomed lake vessel, classified as a gondola, was under the command of General Benedict Arnold when sunk by

British gunfire in October, 1776. The vessel was raised and displayed aboard a barge for years before being donated to the Smithsonian Institution in 1961, where it is still on display at the Museum of American History, Washington, DC (Figure 7.39). The hull measures 53' in length, roughly the same size as the Brown's Ferry Vessel (Sands 1988:152). Although the Philadelphia dates to the time period of interest, it has little relevance to the present study.

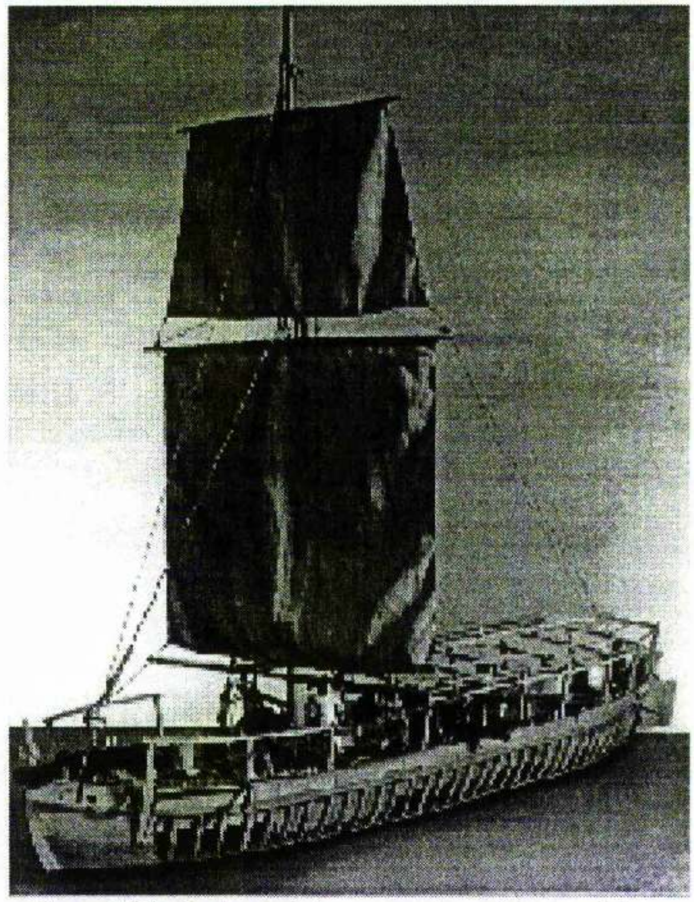


Figure 7.39. Scale model recostruction of the gondola Philadelphia *(Bass 1988:154).*

Sparrow Hawk: The remains of this small vessel are preserved in Plymouth, Massachusetts. Purported to be the English vessel *Sparrow Hawk*, a small ketch lost of Cape Cod in 1626 (Steffy 1988:113-114). The hull exhibits offset first futtocks, not fastened to the floors. The first documented mention of offset first futtocks is by Sir Henry Mainwaring in his 1621 marine dictionary (cited in Baker 1955:24). A second reference may be found in fragments of a manuscript by Thomas Fagge, Esq. that has been dated to c. 1693 (*Ibid.*).

Ticonderoga: Another vessel recovered from Lake Champlain is the United States schooner *Ticonderoga*, built in Vergennes, Vermont in 1814 (Crissman 1983:10; Cassavoy and Crissman 1988:183-185). *Ticonderoga* survived the war, only to succumb to the neglect of the subsequent peace, settling to the bottom of the Poultney River in 1825 (Crisman 1983:32-33). Raised by the city of Whitehall, New York, in 1958, the *Ticonderoga*'s remains were once again neglected, being afforded no conservation treatment and little pro-

Figure 7.40. Hull remains of the Ticonderoga *(Bass 1988:177).*

tection against the elements (*Ibid*.:35). Nevertheless the surviving fabric, surveyed and recorded in 1981, revealed construction techniques that are of interest to the present study (Figure 7.40). The floors are set on 2' centers and average approximately 8" x 7" cross-section. The first futtocks, approximately the same size, have their heels offset from the centerline of the keel by an average of one foot. The first futtocks are fastened to the floors by lateral bolts. There are no intermediate frames, that is, all frames are compound frames. Forward of the master couple, or midships frame, the first futtocks are placed aft of their associated floors, while aft of the midships frame the first futtocks are forward of their floors *Ibid*.:51-55). This is the reverse of the standard configuration for most British merchant vessels, but not completely unique. The midships frame is set extremely far forward, possibly because the hull was originally being built as a steamship, not a sailing schooner.

Trincomalee: Built in 1817 at the Bombay Dockyard of the English East India Company; the *Leda* Class frigate *Trincomalee* was constructed entirely of teak, as a means of dealing with the timber shortage in England (Horton 1979:2; Lyon 1993:119). In 1897, after 80 years of service, *Trincomalee* was sold "for breaking up," but was saved from the wrecking yard when purchased by G. Wheatley Cobb, renamed *Foudroyant*, and used as a training ship at Portsmouth (Horton 1979:15). *Trincomalee*, currently being fully restored at West Hartlepool, was a nineteenth-century foreign-built frigate of 1066 tons and 38 guns and, therefore, not very relevant to this study; however it is mentioned because of its significance and because of the fact that it is the oldest British warship still afloat (*Ibid*.).

Unicorn: HMS *Unicorn* was launched at H.M. Dockyard, Chatham, in 1824. It was built as a *Leda* Class frigate, ironically the same class as *Trincoma-lee*, rated for 38 guns; she was completed, however, at a time of peace during which the Royal Navy was stagnant. As a result, *Unicorn* was never fully fitted out for service. The ship is still afloat and on exhibit in Dundee, Scotland. It is shown in Figure 7.41 with a roundhouse-like structure covering much of the deck so the hulk could be used as a naval reserve unit headquarters. *Unicorn* exhibits a number of technological innovations that took place at the beginning of the nineteenth century under the influence of Sir Robert Seppings, Surveyor to the Navy from 1813 to 1832,

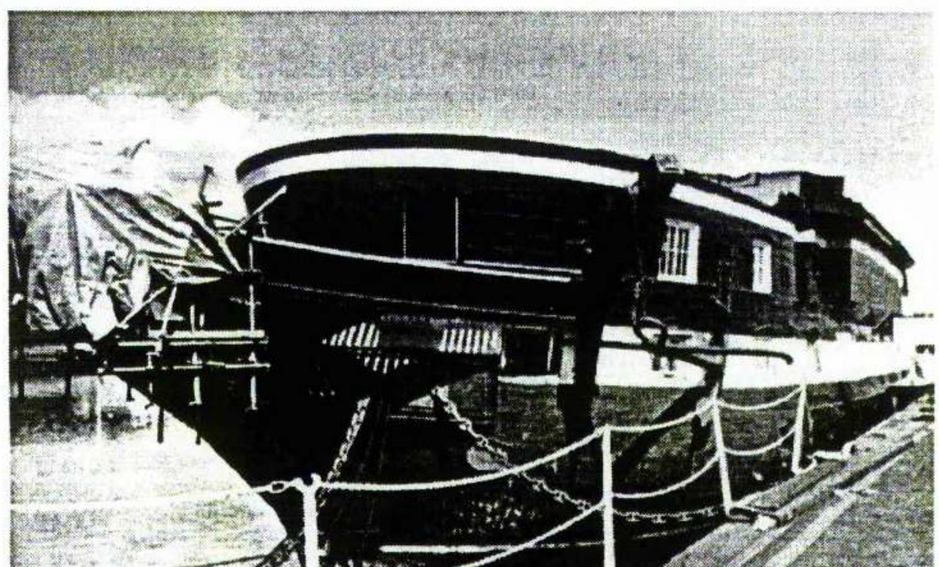


Figure 7.41. Photograph of the Unicorn *at Dundee, Scotland (Muckelroy 1980:91).*

including iron knees, diagonal bracing and a stronger, rounded stern (Lyon 1993:120; Muckelroy 1980:91). Unfortunately, those very innovations make *Unicorn* unsuitable for the present study.

HMS *Victory*: The warship that would one day be remembered as "Nelson's *Victory*" was launched somewhat unceremoniously on May 7, 1765, at Chatham Dockyard. *Victory* was a First Rate ship of 100 guns and rated at $2162^{22}/_{94}$ tons (Bugler 1966:11; Lyon 1993:64).

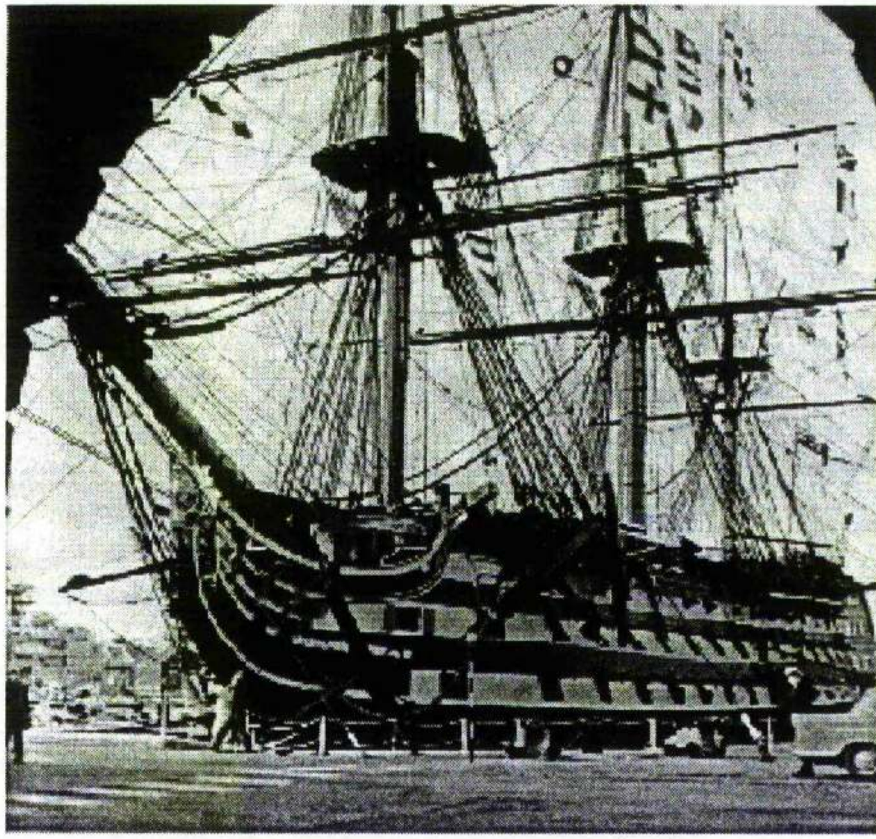


Figure 7.42. Photograph of HMS Victory *at Portsmouth (Bugler 1966:frontispiece).*

In January, 1922, after a long career and many idle years, the *Victory* was placed in permanent dry dock in No. 2 Dock, H.M. Dockyard, Portsmouth. There she has remained, still in commission and still magnificent in appearance. Bugler (1966) describes the *Victory*'s history, especially the many repair and restoration phases the ship has undergone over the years. He also describes the hull, fittings, repairs and restorations in great detail and with good illustrations and an excellent set of plates, bound in a companion volume.

Because the *Victory* is one of the largest of eighteenth-century wooden warships, care must be taken in comparing her to the average merchant vessel of the period. Nevertheless, Bugler's book contains very useful information on the ship's construction, especially in Chapter 7, "Structural particulars and repairs, 1900-64" (Ibid:95-160). This chapter describes the repairs made in this century in great detail, with separate sections covering each area of the ship (beakhead, stern, keel, etc.).

According to Bugler (*Ibid.*:109), the major portion of the keel is probably the original English elm keel laid down in 1759. It is 1'8" wide for most of its length and varies in depth from 1'10" to 1'7$^{1}/_{2}$" and is composed of eight segments. The frames were originally oak with copper fastenings below the waterline and iron ones above, supplemented with treenails (Ibid.:113). Most, if not all have been replaced, some with oak, but most with teak. During the repairs of 1955-64, it was noted that the original frames from stations 25 to 117 were arranged in pairs (Figure 7.42). One consisted of a floor across the hog (deadwood over the keel), plus two futtocks and a toptimber each side; the other was made up of three futtocks and a toptimber each side. The two first futtocks butted to the side of the hog and connected by an "anchor joint" across the hog. As shown in Figure 7.43, three different frame types were encountered, distinguished by the method of joining the futtocks and crossing the keel (Ibid.:114-115).

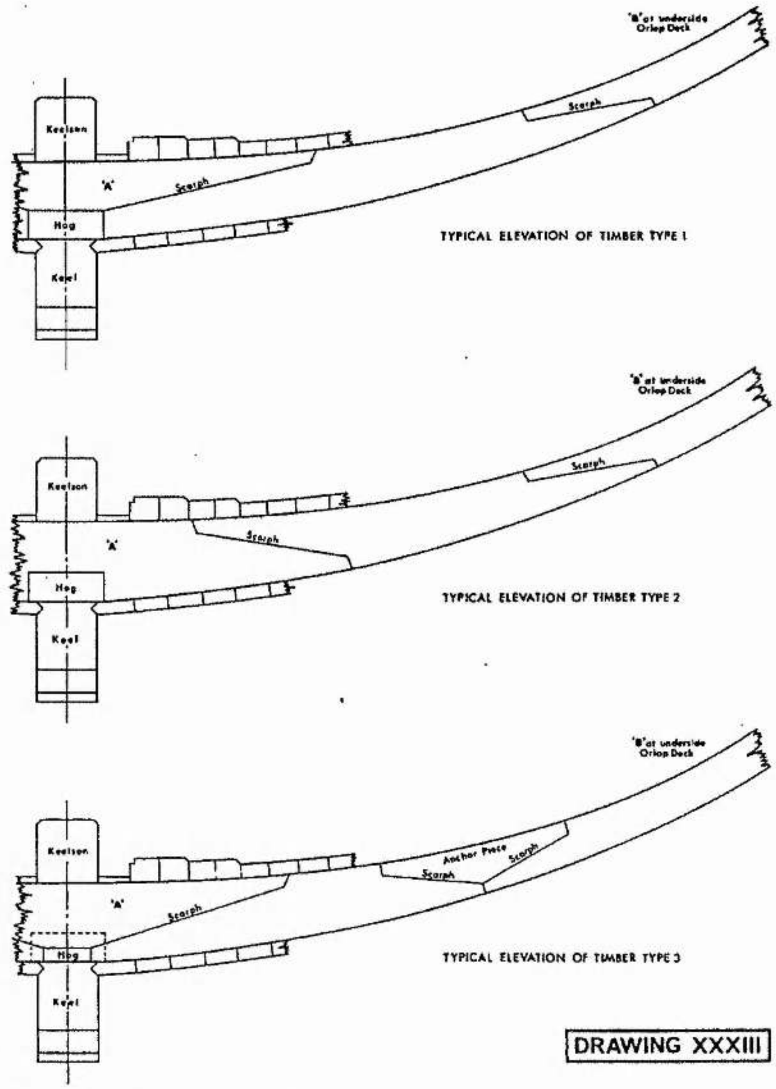


Figure 7.43. Three frames from the Victory *(Bugler 1966:115).*

Bugler's book is an excellent reference that contains much more information on the *Victory*'s construction, but no more needs to be detailed herein. Sadly, very little of the original fabric remains, and the accuracy of much of the restoration is in doubt.

Summary

This chapter has briefly described a number of vessels and shipwrecks from the late seventeenth to early nineteenth century. An attempt has been made to discuss the features and measurements that would be most relevant in better defining eighteenth-century English merchant vessels. Table 7.4 compares the scantlings of the *Betsy*, Slufter Site SL4 and the Bermuda Shipwreck. It is interesting to note that the *Betsy*'s structural timbers and those of the Bermuda wreck were similar in proportion to their hull size, and both were more heavily constructed than the Slufter SL4 wreck, which was probably built a half-century later.

TABLE 7.4
COMPARISON OF SCANTLINGS OF THE *BETSY* AND OTHER VESSELS

Scantling	***Betsy***	**SL 4**	**Bermuda Wreck**
Keel: sided	**14 3/8"**	11"	16" (w/hog 19 1/2"
molded	**13 1/4"**	14-15"	12" x 10")
False Keel (Shoe)	**none (?)**	none	?
Keelson: sided	**14 3/8"**	11" (with same	18"
molded	**15 5/8"**	size rider)	12 1/2"
Floors: sided	**11-14"**	11-12"	12"
molded	**14-16"**	11-12"	12-13"
Outer planking: thick	**3 1/2"**	2 1/2-3 1/2"	3"
wide	**8-12"**	10-12"	11 7/8-12 1/4"
Ceiling planking: thick	**2 1/2"**	2 1/2"	3"
wide	**8-11"**	10-11"	5 1/2-12 1/2"
Estimated Tonnage	**176**	**300?**	**222?**

Notes on Chapter 7

[1] Following the convention established for this document, English units will be used throughout.

[2] This tonnage was calculated using the estimated dimensions in Adams *et al.* (1990) and using the Builder's Old Method (See Appendix A); Adams derived a similar tonnage.

[3] This formula is a simplified reduction of the formula as normally written, as discussed in Appendix A.

[4] The Navy Board draught of the *Industry* did not show keel or stem scarfs, presumably because the vessel's lines were taken off while it was still in the water; however, the position of the scarf was easily estimated, based upon other contemporary draughts.

[5] This armament, which appears too heavy for such as small vessel, was taken directly from the Deptford draught.

[6] MacGregor (1985:31) points out that the majority of privateers—the first seven examples—presented by Chapman(1768) are frigates, obviously vessels that were built for speed.

[7] Much of the information on the *General Carlton* was obtained from Stolpe and Achenbach 1997:50-53, and the English-language translation published on the World Wide Web at URL http://www.abc.se/~m10354/mar/gdansk/wrak32.htm.

[8] Letter and site plan from Waldemar Ossowski, archaeologist, Polish Maritime Museum, dated November 10, 1997.

[9] A more conventional term is "mold frames," as used in this study.

[10] Small vessels built by the whole molding process almost certainly had all their frames — not just some of them—formed using the mold-and-batten developed for the hull (Sarsfield 1991:141).

[11] This treenail diameter of 1.75" seems excessive; $1^1/_8$" would have been more standard.

Chapter 8

A General Characterization of British Merchant Vessels from the Eighteenth Century

This study of eighteenth-century English merchant vessels developed from the need to interpret archaeological data from a large-scale investigation, conducted during the 1980s under the author's direction. Nine British vessels, sunk in October, 1781, during the Battle of Yorktown (Virginia) were located and surveyed; seven of the nine were merchant vessels leased for service as naval transports. Of those, the best-preserved, site 44YO88, was completely excavated and eventually identified as the *Betsy*, an English collier brig built in 1772 in Whitehaven, a shipbuilding center of northwestern England. The hull remains, preserved to just above the waterline, contained some unusual construction features that required extensive comparative research.

Prior to this study, the prevailing belief was that scant information was available on merchant vessels from the seventeenth and eighteenth centuries. Compounding this problem was a basic disagreement among scholars concerning the evolution of shipbuilding in northern England during this period. Davis (1962:71) and McGowan (1981:56) hypothesized that eighteenth-century English merchant vessels were adapted from seventeenth-century Dutch *fluyts* and were a radically-improved merchant vessel capable of operating efficiently with a smaller crew yet carrying more cargo than previous English vessels. If such were the case, it was expected that the *Betsy* should reflect Davis's new vessel type.

To test that theory it was necessary to develop a description of English merchant vessels from the beginning of the eighteenth century to which the *Betsy* could be compared.

Contrary to initial indications, it has been possible to amass a wealth of information on seventeenth- and eighteenth-century merchant vessels built in England or her colonies. This information came from a wide range of historical sources and has been buttressed by increasingly-abundant archaeological information. Analysis of the available data has made it clear that there is little evidence to support Davis's interpretation of English merchant vessel evolution. At the same time, however, it also became clear that sufficient information was available to permit the present author to develop a more complete picture of the construction and evolution of eighteenth-century English merchant sailing vessels than was currently available. Such a study, it was believed, could serve as a guide to other researchers, especially archaeologists in the field, for the classification and analysis of hull forms and construction details from this period.

This concluding chapter summarizes the evolutionary trends of English merchant vessels in light of the new information acquired from archival and archaeological data. In addition, information on hull form and construction are summarized and contemporary treatises are contrasted against archaeological evidence from the Yorktown shipwrecks and other shipwreck sites worldwide. Finally, suggestions are offered for profitable future courses of study.

A Summary of Naval Architectural Theory and Practice in the Eighteenth Century

There is an abundance of evidence to confirm that both design and construction of merchant vessels during the eighteenth century were conducted with few universal rules. Several facts concerning English merchant shipbuilding in the eighteenth century can be stated with reasonable certainty: first, no mathematical theories were in widespread use; second, numerous factors, some very valid, were responsible for the lack of theory; and third, the inescapable conclusion is that the English shipbuilding industry produced no revolutionary new vessel type during the eighteenth century.

Contemporary writers were almost universal in their insistence that mathematical theory played little role in the English commercial shipbuilding industry in the seventeenth and eighteenth centuries. In his lengthy introduction to *A History of Naval Architecture,* Fincham (1851:li) outlined the theories and experiments that contributed to the state of the art of shipbuilding and concluded that, although much progress had been made, even by the late eighteenth century "it seems that there was scarcely a quality that could be ensured to ships from calculation." Fincham (*Ibid.*:lxxxiii) summarized the situation at the time of his writing as follows:

> In looking at the progress of naval architecture, we see that theory has been scarcely an object of study in England; and we are forced to the inference that an adequate cause must have existed for the prevailing indifference to science. The cause has prevailed, and continues to exist; for, to a great extent, the effect still exists. ... From the latter part of the seventeenth century, the usage of the service was to determine the construction of ships by the regulations of office. This necessarily excluded science, and discouraged scientific education. ... This state of things continued till the beginning of the present century ....

In the late seventeenth and early eighteenth centuries, even though development and experimentation were taking place in Europe, and especially in France where many theoretical treatises on various aspects of ship design were published, most English shipwrights either ignored or were ignorant of this information (Fincham 1851:xv). In support of this view, Fincham (*Ibid.*) cited Hoste's treatise of 1697 which complained that even at the end of the seventeenth century bows and sterns were still formed "almost entirely by eye...."

Although Fincham (1851) principally discusses naval vessels, it is clear that his introduction is intended to apply to the design and construction of merchant vessels as well. Although he does not discuss commercial vessels in detail, it is safe to assume that most merchant builders were not restricted in their designs and building practices "by the regulations of office;" but, at the same time most were probably ignorant of the academic treatises and experiments that were beginning to formulate a theoretical foundation for the scientific design of efficient sailing vessels.

Chapman (*Ibid.*:76), in his *Tractat*, added his authoritative opinion on the lack of theory stating,

> It thus appears, that the construction of a ship with more or less good qualities, is a matter of chance and not of previous design, and it hence follows, that as long as we are without a good theory on shipbuilding, and have nothing to trust to beyond bare experiments and trials, this art cannot be expected to acquire any greater perfection, than it possesses at present

Charnock, in his three-volume *History of Marine Architecture* (1800-1802:II:477) also supported these views and indicated that toward the end of the seventeenth century naval architecture in Europe was becoming more standardized but that such standardization was not the norm in England.

There were reasons for the apparent slowness, or even reluctance, of English shipwrights in adopting newer European theories. The two most obvious and insurmountable were that those theories were not widely disseminated in England during the eighteenth century and, as Charnock lamented, even if the principal treatises had been readily available few, especially in the merchant yards, would have been able to comprehend or apply them. There were other reasons as well, relating primarily to the mind-set of the builders. First of all, there would have been a natural resistance to altering building methods that had served them well, particularly since they were producing vessels that answered their purchasers's needs. Such inertia is always difficult to overcome. Also, merchant shipwrights undoubtedly suspected, and may have had reason to believe, that the new theories did not always produce a better vessel. There was another important factor underlying the response of English shipwrights: the desire to protect their own designs and practices for competitive advantage. These explanations can be found in the writings of the men who closely observed the shipbuilding industry.

At the beginning of the nineteenth century Steel (1805:iii[fn]) wrote of the lack of mathematical and theoretical skills among English shipwrights,

> The illustrious Chapman, of Sweden, whose works, if translated, would, however, be of little value in this country; since they are not to be understood without a previous acquaintance with the higher branches of the mathematics, of which very little is known among our artists ....

Chapman's treatise of 1768 was not, in fact, translated into English until 1820 (Ingram 1820), and it is doubtful that the document was widely distributed.

Stalkartt (1781) expressed his belief that resistance to change was responsible for the lack of standardization:

> In the Theory of the Art there are no fixed and positive principles established by demonstration, and confirmed by use. There is hardly a rule sanctified by common consent; but the Artist is left to the exercise of his own opinion, and this generally becomes so rooted by habit, as to resist innovation, however specious.

In 1830, a time many consider to have enjoyed the advantage of long-evolved, widely-accepted and relatively standard rules for shipbuilding, Hedderwick (1830:146) wrote that secretiveness among merchant builders was inhibiting standardization and progress:

> We should not be surprised to find a variation in the proportions of merchant vessels, when we consider there has never been any established rule given for these dimensions, and that they are built by persons who are rivals in trade, and endeavour to keep their principles to themselves, if they think them superior to their neighbours.

There were other, quite valid, reasons why English shipwrights were not quick to embrace the new European theories. According to Chapman (1775:75-77), the development of improved theories on ship design did not, by any means, ensure that the vessels afterwards constructed would possess correspondingly improved qualities:

> [The theory of shipbuilding] has one great difficulty ... namely, that even after following the theory with the greatest exactness ... in conformity with all the rules [in building a vessel] ... it may nevertheless happen, that such a vessel will answer very ill .... Lastly, it is evident from all that has been said, that a ship of the best form, will not shew its good qualities, except it is at the same time well rigged, well stowed, and well worked by those who command it.

Not only was there uncertainty about the performance of a vessel, once launched, there was even a possibility that the vessel would not be adequately stable. (Fincham 1851:xvi) reported that eighteenth-century French ships, in spite of the efforts of French theorists, were often unstable and required doubling—adding a layer of thick planks to the outer hull to increase the beam—before they could be put into service. There were also similar descriptions of the doubling of English warships. Fincham (*Ibid.*:xxvii-xxxix) discussed stability at length, providing descriptions on the various and largely erroneous attempts to derive a mathematical means of developing adequate design criteria for stability.

There was also contemporary evidence that at least part of the conservative response among English shipwrights was simply that what they were doing was working. In spite of the numerous complaints during the eighteenth century concerning England's lack of theoretical foundation in the art of ship design, there are also indications that the English merchant marine was strong and that shipyards were constructing functional vessels. Charnock (1800-02:III:32) presented a fairly optimistic view of the commercial shipbuilding industry in England in the eighteenth century:

> At the beginning of the eighteenth century ... The commercial marine of Europe, taking the whole of it in the aggregate, kept pace with the navies belonging to the different states .... [Periodic fluctuation] trivially affected the principles adopted in constructing vessels intended for mercantile purposes; the whole, or at least the strongest part of human efforts, being directed to the number of them.

Charnock (*Ibid.*:202-3) also asserted, "The commercial marine [in the mid-eighteenth century] was by no means behind that of the state, in respect to the improvements introduced into it. The rapidity of their adoption in the latter, far exceeded what took place in the former class ...." As to the ships being built by the state at that time, Ollivier (Roberts 1992), reporting to France on British shipbuilding in 1737, stated that he was favorably impressed with many aspects of British warship construction.

Although contemporary treatises and histories agree that steady, if not impressive, progress was made in shipbuilding during the eighteenth century, they provide no strong *written* evidence whatsoever for the emergence of a radically new type of English merchant vessel during that period. Chapman, in the Author's Preface to his *Tractat* (Ingram 1820:75), made a strong statement on the lack of technological advances in shipbuilding during the eighteenth century when he wrote:

> If we were to take a view of the immense number of ships that have been built, since mankind first began to navigate upon the ocean, and note all the different steps, which have been taken in improving their construction, we should at first be inclined to believe, that the art of ship-building had, at length, been brought to the utmost perfection. An opinion that would receive additional force from a consideration of the few essential alterations, which have been introduced either in their form or rigging, during our own age.

Could it be possible that the modifications to merchant vessels in the eighteenth century were sufficient to produce a significant improvement in performance and efficiency, yet were introduced so gradually through experiment and diffusion that the resulting improvements escaped the notice of the theorists and authors? Could these changes have originated primarily in the merchant shipyards in the north of England, the area identified by nearly all sources as the new center for merchant shipbuilding during the century? Before those questions can be adequately addressed, it will be necessary to examine contemporary hull forms and rigs more carefully.

A Summary of Eighteenth-Century Hull Forms and Rigs

Hedderwick (1830:355) provided what is probably the best overall general description of eighteenth-century merchant vessels to be found in any contemporary document:

> Vessels in the coal and coasting trade are generally of a broader and lower construction than those in the foreign trade, on account that a greater stability is required, these having often to perform one half their passages in a ballast-trim; also, as they are more frequently beating to windward in narrow channels, in which case narrow sails are found to answer best, as the ship will lie closer to the wind, and sail faster, than with the same quantity of canvas in a broader sail, when laid with the same angle to the wind; also the yards being shorter, are lighter and easier braced round, which is a great advantage in navigating narrow channels.
>
> Ships for the foreign service are commonly built deeper in the hold, to give room for some particular stowage, and in general they have less stability than coasting vessels of the same size; therefore their masts are rather shorter, and their yards longer, by which they are enabled to spread an equal surface of sail in proportion.

Hedderwick's brief description speaks volumes on the reasoning behind the successful survival of many different types of commercial vessel hull forms and rigs. When considered along with other pragmatic and economic factors such as characteristics of the cargo (weight per volume, perishability, value, susceptibility to water damage, etc.), duration of a typical journey (local, several weeks, several months), type of waters to be navigated (inland, shallow coastal, deep coastal, etc.), special requirements (fishing, whaling, etc.), resources of the purchaser of the vessel, etc., one can readily comprehend that an entire range of vessel types and sizes is required to meet the myriad of special needs, even today (Figure 8.1).

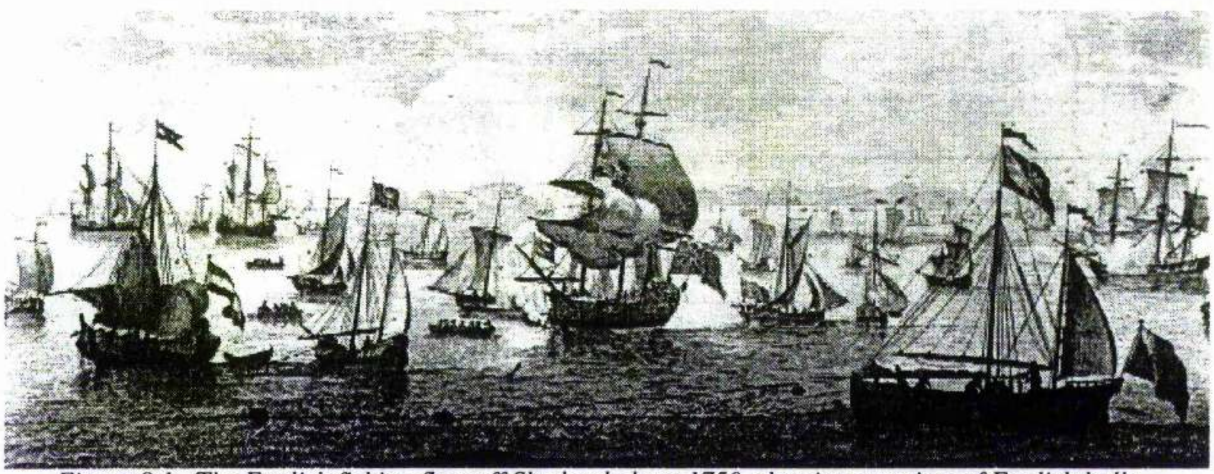


Figure 8.1. The English fishing fleet off Shetland about 1750, showing a variety of English hulls and rigs, including a few larger ship-rigged vessels that may be the fishery protection squadron; a number of Dutch vessels are also illustrated on the left (National Maritime Museum).

Merchant Vessel Classes

Chapman (1768) groups merchant vessels into five principal classes: frigate, hagboat (heckboat), pink, cat and bark. These classes are based on hull form, which he illustrates with a variety of sizes and rigs (Figure 8.2). *The Shipbuilder's Repository* (Anonymous 1788:116-122) classifies merchant vessels into four classes based on size (tonnage), and concentrates on three-masted ships, with little information on other rigs. Steel (1805:180) declares,

> Of Merchant Shipping, in general, being scarcely definable into distinct classes, we cannot speak with that degree of precision as of those of the Royal Navy; because their respective forms and dimensions are dependent, almost entirely, on the local practice or ideas of their respective constructors, and fluctuate accordingly.

Steel (Ibid.:124) also states that "[m]erchant ships are generally constructed to carry a certain cargo, and their principal dimensions are determined according to the trade for which they are particularly designed...." As in the above statement, he also avoids mention of vessel types or classes in this latter context.

Hedderwick (1830:146) described the form of merchant vessels as follows:

> In general, merchant vessels are a little varied in their principal dimensions, according to the particular trade for which they are intended, and thus naturally form separate classes. Among the vessels of each class, there may be a little variation.

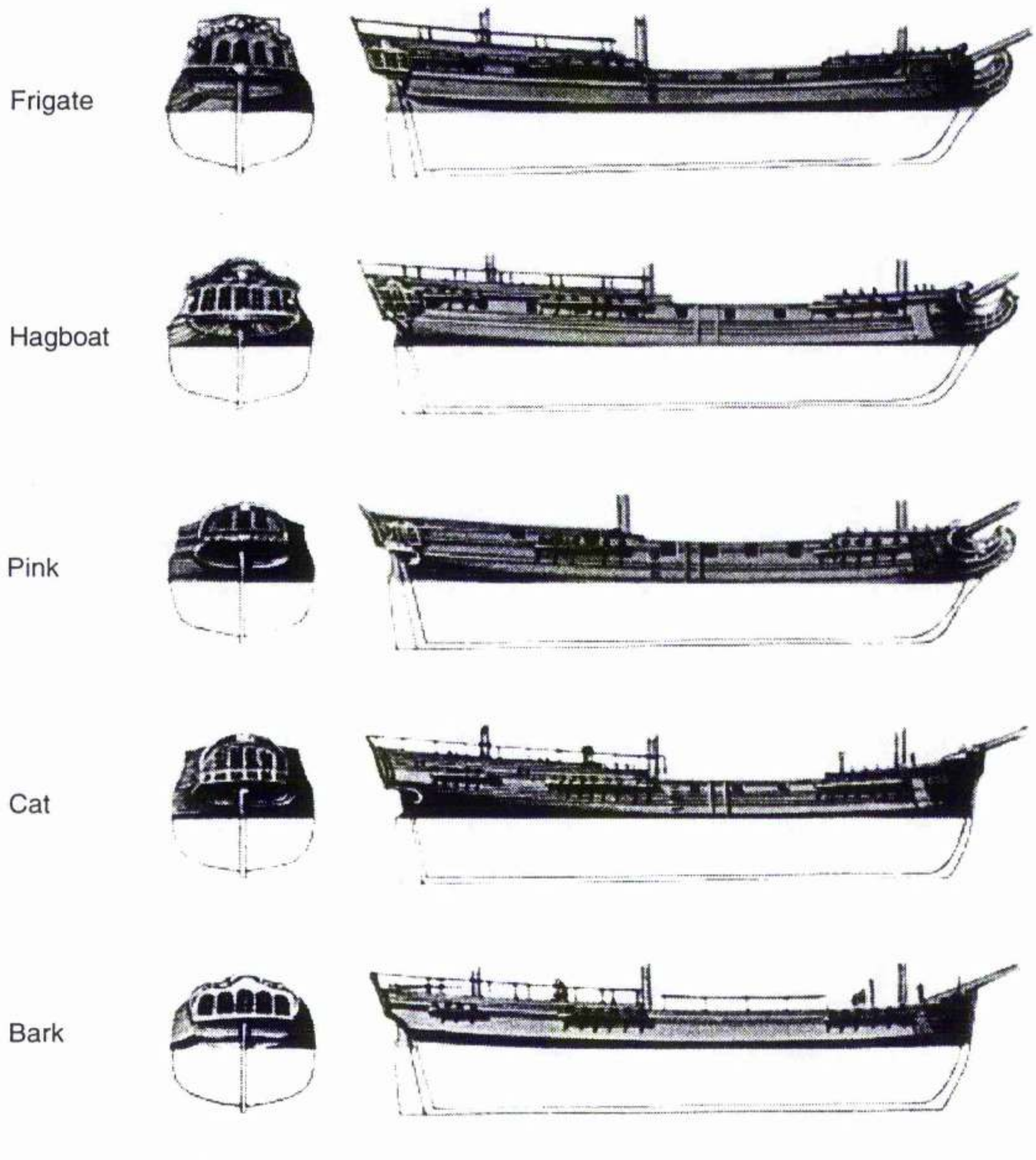


Figure 8.2. Modern illustrations accurately depicting the five eighteenth-century merchant vessel classes described byChapman, 1768 (Illustrated in Landström 1961:172-173).

Hedderwick (*Ibid.*) then defined the classes of merchant vessels by their rig, as follows:

> The largest of our vessels have seldom more than three masts. It is by the number of the masts, and the particular cut of their sails, that they are denominated. Thus vessels with three masts are called Ships or Barks—with two masts, Brigs, Schooners, or Shallops—with one mast, Sloops, Cutters, or Smacks.

Hull Forms

In spite of this wide variability, Chapman (1775:75) states that oceangoing ships, regardless of the country of origin, have numerous qualities in common, and that "being built for the same purposes, they are similar in their essential parts." He lists the following:

1. Their breadth is between one-third and one-fourth of their length,
2. The smallest have proportionally greater breadth than the largest,
3. Their draught is more or less half their breadth,
4. Their height out of water varies considerably with function, but has limits,
5. Their accommodations have great similarity,
6. They have their greatest breadth a little before the middle,
7. They are leaner aft than forward,
8. Those designed for ships of burthen are fuller in the bottom,
9. Those built for sailing are leaner there,
10. Their stem and stern-post have a rake,
11. They have a greater draught of water aft than forward,
12. Most have three masts, others two, and some only one,
13. Their masts have nearly the same proportions and the same placement,
14. They are rigged generally in the same manner,
15. All have their center of gravity a little before the middle of their length, and
16. The center of gravity of their sails is always before the center of gravity of the vessel.

After stating these numerous similarities, Chapman (*Ibid.*) cautions:

> In this manner all ships designed for navigating in the open sea are constructed; and as this mode of construction is the result of an infinite number of trials and experiments, and of alterations made in consequence thereof, it would be improper to infringe on limits so established.

As discussed in Chapter 1, most of the contemporary treatises offered a list of basic qualities that should be possessed by all sailing vessels. For instance, Chapman (*Ibid.*:xii) listed the following as necessary criteria for the design of a proper merchant vessel:

> A merchant ship ought:
>
> 1. To be able to carry a great lading in proportion to its size,
> 2. To sail well by the wind, in order to beat easily off a coast where it may be embayed, and also to come about well in a hollow sea,
> 3. To work with a crew small in number in proportion to its cargo, and
> 4. To be able to sail with a small quantity of ballast.

He then discusses the difficulties in satisfying all these criteria simultaneously, summarizing that:

> ... we can conclude nothing concerning the length, breadth, and depth of ships, since different qualities require conditions diametrically opposed to each other .... Wherefore, for a merchant ship, it is necessary to combine these qualities, so that it may have the most possible of each (1775:84).

Similarly, *The Shipbuilder's Repository* (Anonymous 1788:41) lists the following criteria for ship design:

> All ships should have good speed; steer well; feel the least motion of her helm; be "duly poised," or not pitch hard; carry a good press of sail; and sail well before the wind, large, and also keep a good wind close-hauled, without falling off too far leeward. Also, a merchant ship should be able to stow a good cargo.

This list is followed by the statement that "these factors must all be balanced."

Types of Merchant Vessel Rig

As types of rig evolved and became more standardized during the eighteenth century, there was a trend towards identifying merchant vessels by their rig, rather than by their hull form. The shift in classification of merchant vessels from their hull form to their rig began late in the eighteenth century and was complete, more or less, by the second quarter of the nineteenth (See descriptions of the types of rig, Chapter 1).

Hedderwick (*Ibid.*:355) says of the masting of various types of merchant vessels,

> There is a little variation in the lengths of the yards of ships of nearly the same dimension, according to the particular rigg or trade for which they are adapted.

He then describes the philosophies for masting of vessels for various general usages, as quoted at the beginning of this section.

Fincham, in his 1829 *Treatise on Masting Ships* (1829:109), reported that even in the second quarter of the nineteenth century the masting of merchant vessels was highly variable and followed no specific rules:

> In determining the masts for merchant ships, no general rule appears to have been observed, as we find many ships in the same trade, and of the same dimensions, with very different masts and yards; and which, from their form and general cargo, would appear to have about the same stability, and consequently require the same number of men to work them.

He (*Ibid.*) continues, with a comparison of the masting of merchant vessels to that of war-ships, stating:

> In comparing the dimensions of masts and yards of merchant ships with those given to ships of war, we find that instead of the merchant ships (though requiring fewer men to work them, and not needing to sail with the same speed,) having less masts and yards, it is frequently the case that they carry a greater quantity of sail than ships of war, in relation to their principal dimensions ....

Summary

As discussed above, virtually all of the treatises on naval architecture, shipbuilding or masting report variability and lack of accepted rules for the construction and masting of eighteenth-century merchant vessels. Although such a preponderance of evidence can not be overlooked, one must consider that, in spite of such negative assessments, it appears that this variability was within acceptable limits and that the resulting vessels performed their intended functions with reasonable success.

After reviewing contemporary data, there is still no clear evidence that a new vessel type emerged during the period of interest. Is it possible that the changes occurred in the actual construction of the hull, that is, in the size, configuration and fastening of the basic hull components? Did the actual method and process of forming the hull contribute to major hull changes? For answers, an examination will be made of the available evidence, both archival and archaeological, of eighteenth-century hull construction.

Hull Construction Techniques

A review of vessel draughts, drawings and paintings from various sources, along with archaeological evidence, as discussed in previous chapters, confirmed the above contemporary assessments of the variability and lack of specific rules for merchant vessel construction during the eighteenth century. Analysis of the various hull attributes identified and defined in Chapter 2, including both measured and computed coefficients and other values, also supports the conclusion that there was wide disparity in almost all vessel attributes among eighteenth-century merchant vessels, even those that were allegedly of the same "class" or type (See below and Appendices).

Information is limited on the actual techniques and sequences of hull construction as well as on the specific sizes, configuration and assembly of the various components comprising vessels's hulls. However, sufficient information is available to permit an examination of the principal construction techniques and an assessment of how those techniques might have contributed to an improved merchant vessel type during the eighteenth century.

Shell-First Construction

Modern scholars (e.g., Greenhill and Morrison 1995) have determined that the first seagoing vessels were built shell-first, that is, the hulls were formed from planks joined at the edges with mortise-and-tendon fasteners; internal framing was added afterwards for strength, but the frames did not influence the shape of the hull. Although the shell-first method permitted the builder to fashion a hull of suitable form and shape without the need to "loft" the hull in order to pre-shape the frames, the method was extremely labor-intensive and required a high degree of carpentry skill. Nevertheless, the shell-first construction method endured for centuries and is still the method employed for most small craft construction.

Plank-on-Frame Construction

Today, the "rational" and "logical" method of wooden shipbuilding is considered to be that of constructing a strong, interconnected frame over which planking is fastened, outside and in, to form a ship's hull (usually referred to as the "skeleton-first" or "frame-first" method). In fact, if one considers such factors as strength, labor, time, etc., frame-first construction might easily appear to be the most obvious and advantageous method one could conceive. However, such assumptions disregard the fact that only in relatively recent times has there been a theory—much less graphical and mathematical tools—for predetermining the shape of ships's frames. Therefore, one must attempt to envision the technology and "mental templates" of the times when seeking to identify and assess the "best" and "most obvious" methods.

The relatively recent appearance and gradual ascendancy of skeleton-first construction often surprises modern naval architects and historians since, as suggested above, the plank-on-frame system seems to most modern observers to be the most intuitively obvious and simplest method of building a boat or ship. However, when one takes into account that the ancient builder had virtually no concept of building to a predetermined pattern or form, the early "shell-first" techniques appear much more rational.

Steffy (1991:3-7) considers the *Serçe Limani* vessel, that sank c. A. D. 1025, to be the first known example of a hull constructed primarily by the skeleton-first technique.[3] After two full frames and eight additional floor timbers were attached to the keel, lower planking was attached before any futtocks were added. At that stage of construction, cleats were used to support the lower planking. This technique is very similar to that described for several Dutch vessels from six centuries later (Green 1991; Hoving 1991; Oosting 1991) and for a number of archaeological sites as well.

It appears that at least by the seventeenth century, European shipbuilders had adopted the frame-first technique on a widespread basis. Gillmer (1991:90) postulated,

> The acceptance and full understanding of the technique of assembling the ship's transverse frames-first upon the keel was in place in most European communities toward the middle to the end of the 17th century.

Maarleveld (1994:154) stated with confidence that the adoption of frame-first building took root even earlier:

> There is no doubt whatsoever that along the Atlantic seaboard of the Iberian peninsula ocean-going flush-planked ships were built frame-first at least from the fifteenth and sixteenth centuries onwards.

Maarleveld (*Ibid.*) also assumed that the method was adopted in the British Isles around the same time.

Gillmer (1991:95) made the point that the new design and orthographic projection theories that were gaining more widespread acceptance by the eighteenth century were oriented toward frame-first construction. Using the body plan projection most, if not all, frames could be transferred to full-scale on the lofting floor and fashioned; displacement and stability could be calculated, or at least estimated, from the drawings. Therefore, he argued, the new theories encouraged widespread adoption of frame-first techniques. Gillmer (*Ibid.*:91) further stated that by the middle of the seventeenth century use of the three customary orthographic projections of ships's hulls was being introduced in Western Europe.[4]

The evidence suggests that by the second half of the eighteenth century all English warships and East Indiamen were built frame-first, with many or all of the frames fashioned from lofted lines, pre-assembled and erected on the keel. However, it must be questioned if the same was true of the smaller, more remote, merchant shipyards of Europe and England (Figure 8.3). The data examined in the present study clearly verify that frame-first construction was in general use throughout the eighteenth century, and archaeological evidence discussed in this study also illustrates the wide range of ideas and methods applied to the plank-on-frame construction technique. However, let us examine the hull-forming and construction techniques more closely in an effort to identify characteristics that may have contributed to significant changes in vessel performance and efficiency.

Building by "Rack of Eye"

Some contemporary sources assert, or at least suggest, that merchant vessels in small, remote yards, even as late as the eighteenth century, were still built without models or lines, by a method often referred to as building by "rack of eye." This was undoubtedly true for the building of most small craft, but there is no way to determine how widespread the practice was in the construction of oceangoing vessels. Gaskin (1909:234) believed that northern builders employed such informal building practices well into the nineteenth century, stating that until 1836, "all Whitby ships were built "by t' skeg o' t'ee' — by a glance of the eye …."

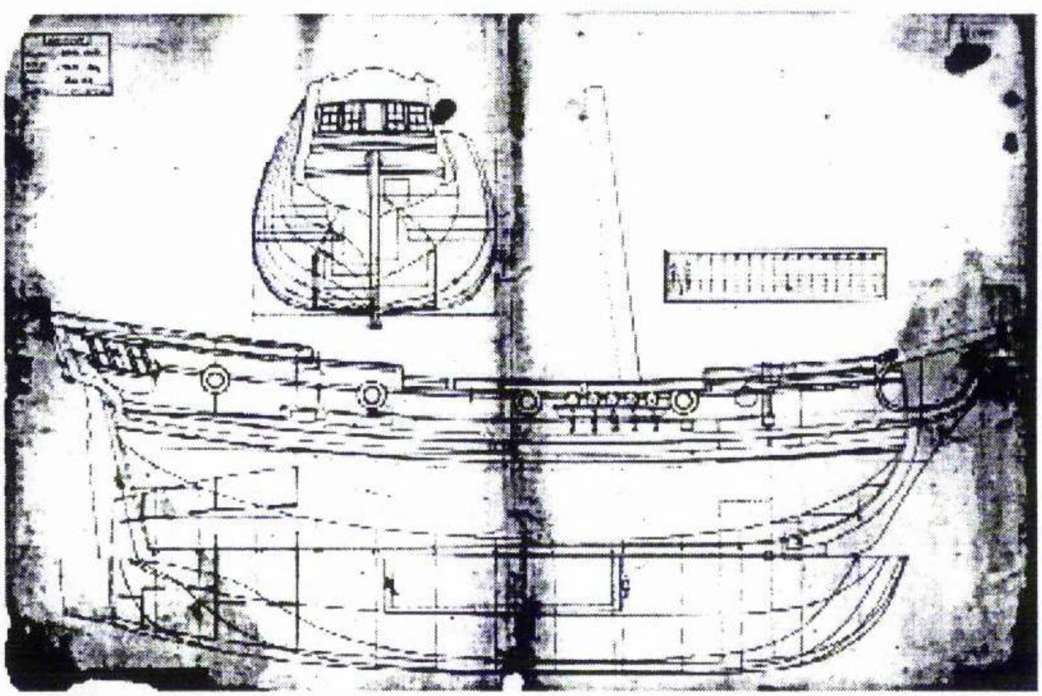


Figure 8.3. One of the earliest lines draughts of a merchant vessel. This is probably the Lyon, a hoy of 108 tons, built at Deptford in 1709. Most of the early draughts of merchant vessels were lines taken off by the Royal Navy of vessels hired, purchased, captured or built for its own use (National Maritime Museum).

Since the construction of merchant vessels was an art passed down from one shipwright to another, and since that art had presumably reached a state of development that satisfied consumer needs, there is every reason to believe that there were eighteenth-century builders launching very practical and functional vessels based on their own training and experience and with no knowledge, or at least with no adoption, of more modern theories and methods.

Conventional Lofting Techniques

A wooden hull could be formed from a three-dimensional scale model or from a set of lines draughts. From either starting point, the stem, stern and frames were drawn full-scale on a large flat surface called the lofting floor. Patterns or molds were then cut to the shape of the component to be fashioned; then the shape was transferred to a suitable timber and the shape was roughly formed with a broad axe or saw. Then the final trimming was done with axe and adze, and the timber was erected on the structure. The first step in frame-first construction was to erect, level and brace the keel and posts. Then frames were added, as they were fashioned from the lofting patterns. At this point, a variety of different techniques was used in obtaining the final vessel form and in completing the construction.

Whole Molding

Another graphical method of determining hull shape was in use during the eighteenth century, that of whole molding (moulding). Hedderwick (1830:221) described this method as follows (Figure 8.4):

> *Whole-Moulding* is a method of drawing the rounding part of all the square-frames by a sweep of the same radius, or with a mould formed to answer this purpose, called the *Bend-mould*. This method of moulding was formerly much used for constructing boats or ships which were narrow abaft, and had a considerable round on the side; but it is quite inapplicable to the draught of ships on the present construction.

In other words, a builder with limited theoretical and drafting skills could form a desirable midships bend, then form the entire hull from a single set of patterns, or molds, simply by moving the patterns in and up along the rising and narrowing lines. This method, although more suitable to small vessels, found employment on full-size merchant vessels, especially early in the eighteenth century and before. Some contemporary treatises state that this method was rarely used on full-size vessels in the eighteenth century while others suggest that it may have actually enjoyed widespread use, possibly in a slightly modified form.

It should be noted that whole molding is not to be confused with the very widely-practiced mold frame construction method that Sarsfield (1991) referred to as the "master frame and ribbands" method, described in the next section. The two methods are quite

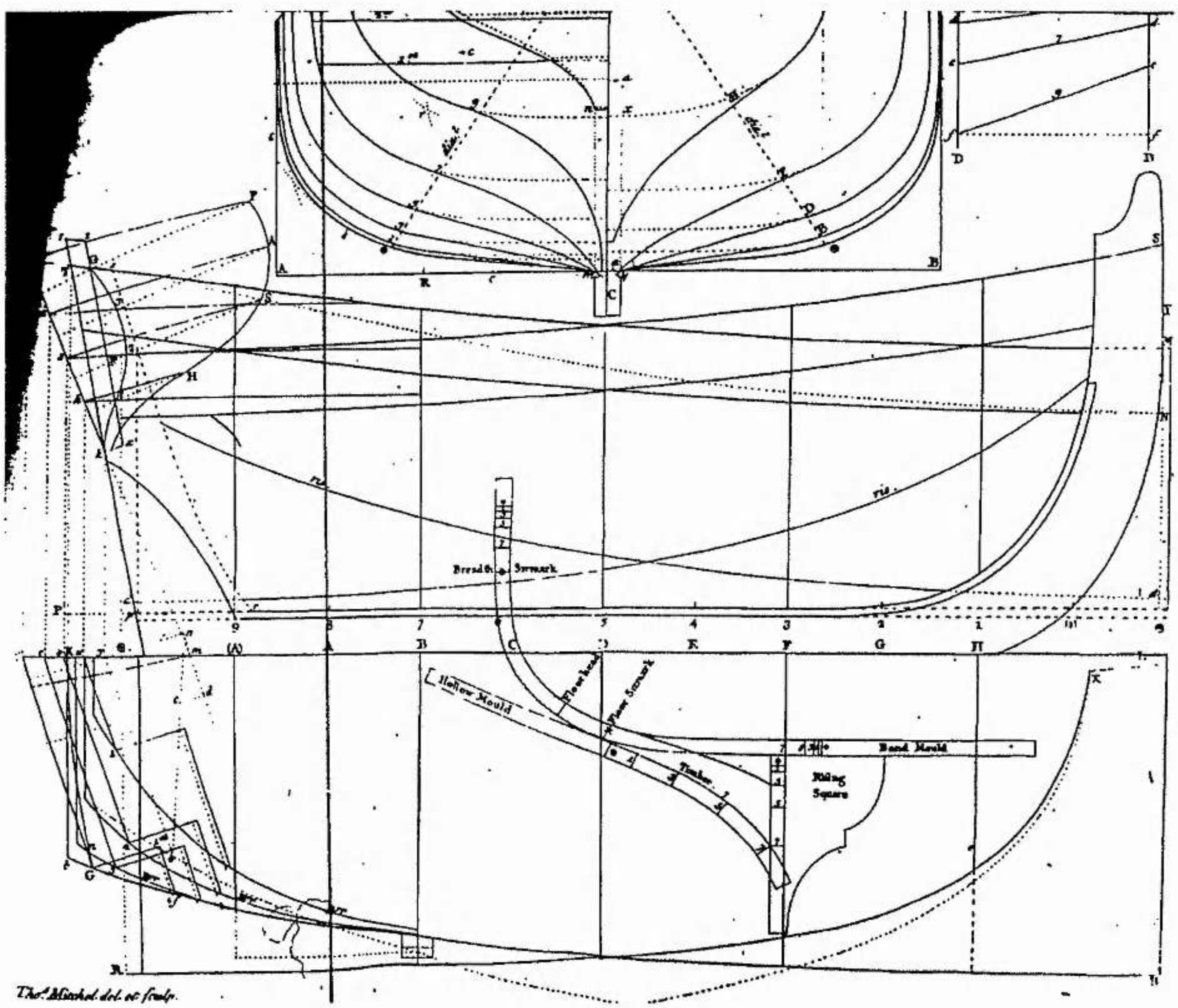


Figure 8.4. Illustration of the technique of whole molding for forming a ships's hull (Murray 1765:173, Plate VI).

different. The presence of mold frames has nothing to do with the whole molding procedure. In fact, as Sarsfield (*Ibid.*:141) indicates, whole molding is the *only* carvel lofting method in which *all* frames are normally lofted from the template.

Mold Frame and Ribband Construction

Based on both archival and archaeological evidence, there can be no question that the vast majority of merchant vessels were constructed using a "hybrid" building technique that combined the basic frame-first method with a modified shell-first approach. First, the "backbone" consisting of the keel, stempost, sternpost and, usually, the counter or stern structure were assembled. Then "master" or "mold" frames were fashioned to predetermined shapes, based on lines draughts or a three-dimensional builder's model, and erected on the keel. The number of mold frames varied (As shown in Figure 8.5, there could be as

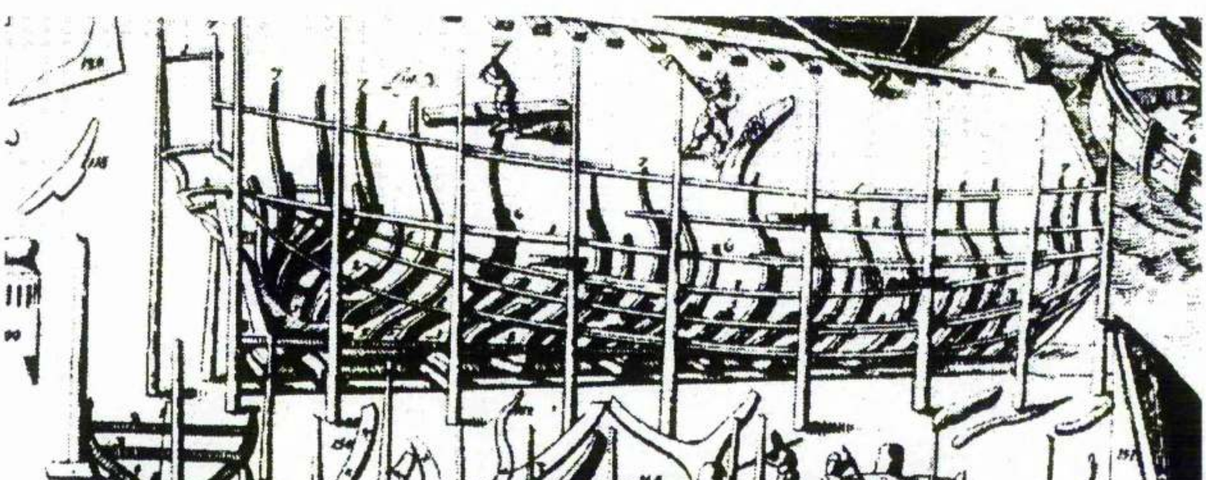


Figure 8.5. Detail from a seventeenth-century Scandanavian shipyard, showing two methods of mold frame and ribband vessel construction (Rålamb 1691).

few as one!) but they were usually placed at intervals along the midbody of the hull, rarely attempting to fashion frames near the extremities. Following erection of these mold frames, the builder would generally fit battens, called ribbands, to the stem, stern and mold frames to define the hull shape. The intermediate, or filling frames were then fabricated by fitting them to the shape formed by the ribbands. There were many variations, some involving fastening wales and/or planking to the mold frames before adding the remaining filling frames, but all followed the same general procedure Figures 8.6 and 8.7).

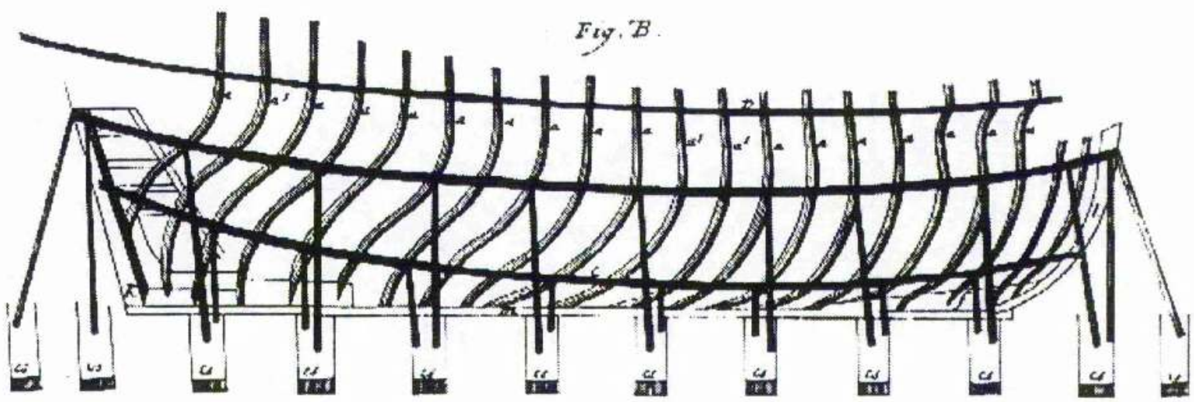


Figure 8.6. Illustration of a vessel under construction, with mold frames and ribbands in place; the author instructs, "Get on first the Frame-timbers, which in Some Ships is every fourth ... then hang up a Ribbon [ribband] ..." (Sutherland 1711:26).

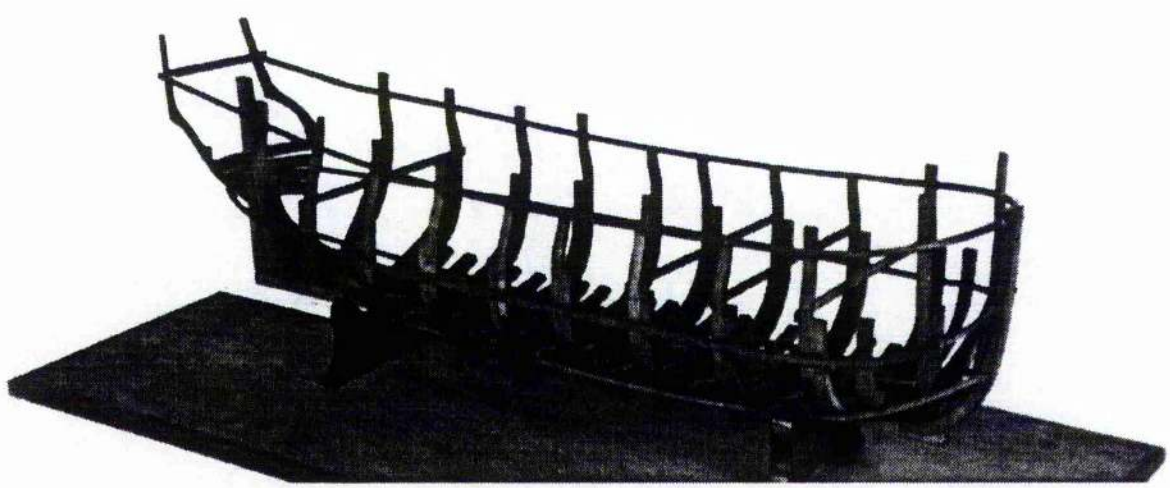


Figure 8.7. Model of a collier in frame, ca. 1820, showing mold frames, battens and filling floors in place (NMM:Neg. No. C2804).

Hedderwick (1830:272) explained that the method of using "whole frames," or mold frames, interspersed with "filling-in timbers" was still very much in use at the time he prepared his treatise:

> We have considered every other floor to be made a frame, which is the most common case, and is found to answer very well; but in building a fine vessel, I recommend that the timbers be all properly joined together, so as to make the whole frames, fore and aft, having only a few timbers to fill in, in the way of the luff of the bow and quarters after the frames are up.

A century earlier, Sutherland (1711:26) stated that the "Frame-timbers" or mold frames "in some Ships is every fourth, and in some every third." Archaeological evidence suggests that Sutherland's specifications are more accurate for the eighteenth century.

Modern scholars have just begun to understand the full significance and widespread application of this mold-frame construction method. Sarsfield (1991:137-145) describes this framing system in detail, referring to it as the "master frame and ribbands" method. He claims that this method is "the simplest and perhaps even the oldest method of carvel building ...." He then describes the method as it is still practiced in many parts of the western hemisphere.

Evolution of Framing Patterns

Morris, Watts and Franklin (1995:125-133) utilized archaeological data in developing a hypothesis for the evolution of eighteenth-century framing patterns. Archaeological data were examined from eight shipwreck sites dating from the late-sixteenth century to the early-nineteenth century. In this synthesis the authors defined six configurations for square frames and four for bow cant frames, then identified the configurations employed on each vessel (*Ibid.*) (Figure 8.8). The authors (*Ibid.*:132) readily admit that this study "is neither seamless nor free of exceptions. ... [T]he list of exceptions ... is too lengthy to include." Nevertheless, this study (Ibid.:130-132) is a significant first step in the development of an evolutionary theory that will eventually be indispensable to researchers. The study suggests a pattern of evolution in eighteenth-century hull framing that evolved from single frames to double frames with separate, but paired, components and with the heels of the first futtocks offset from the centerline and room being equal to space.

The authors (*Ibid.*:132) conclude that economic demand was probably the principal factor driving the evolution of merchant vessel framing, and that construction advances would "naturally follow a demand for vessels that were more seaworthy, better suited to specific tasks, and profitable." They also cite other factors, including material availability, advances in technology and demographic shifts. However, the authors did not develop those arguments sufficiently to demonstrate that their hypothetical framing evolution patterns actually represent technological or economic improvements of significance. This study of framing evolution underscores one previous observation: the employment of mold frame and ribband construction was almost universal during the eighteenth century.

Even English warships were constructed with mold frames, inter-

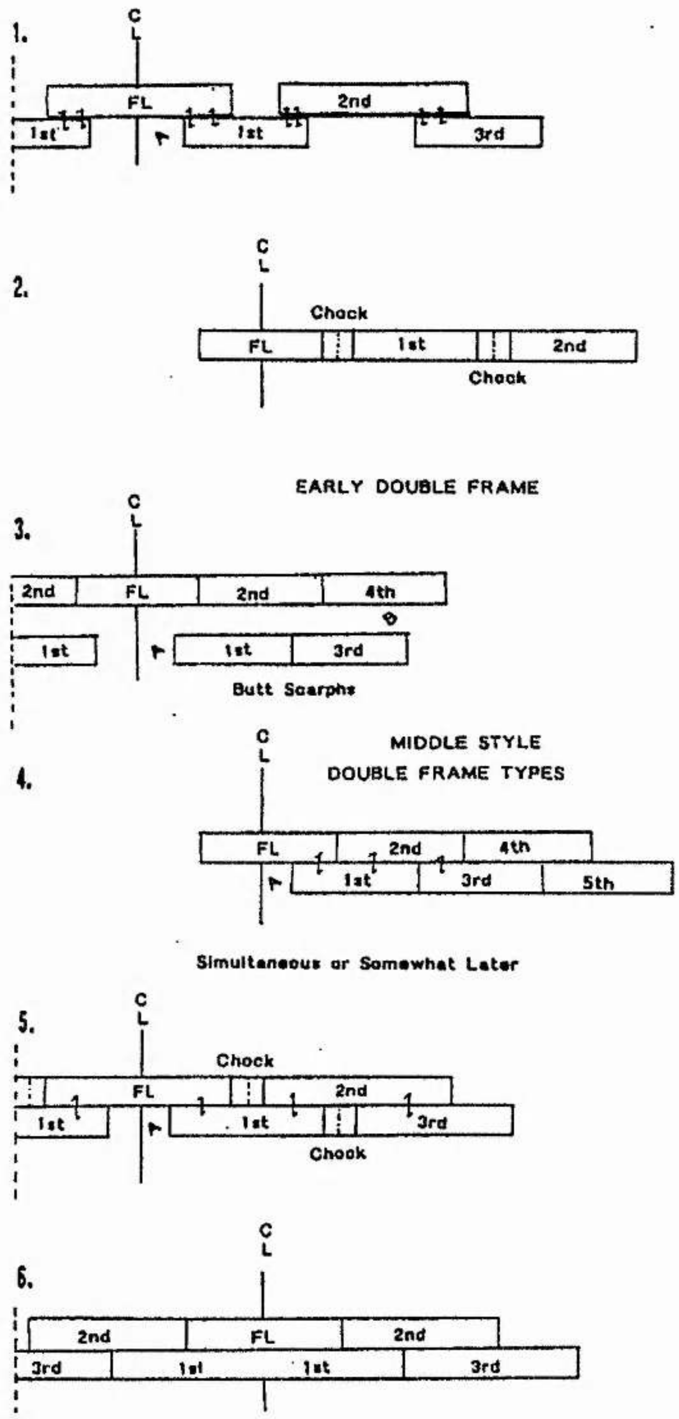


Figure 8.8. Six patterns of eighteenth-century framing evolution (Morris, et al. 1995:128).

spersed with filling frames, until around the middle of the eighteenth century. Ollivier (1737:65), a French "observer," in describing the English method of constructing large warships in 1737, wrote that the English set up molded frames 7, 8 or 9 feet apart, depending upon the size of the ship. First, only the floors of the mold frames were crossed; then first floor ribbands were placed and shored, filling frame floors were added; then first and second futtocks of mold frames were raised and a second ribband added, and the process continued. He said that the futtocks of the filling frames did not form pairs of frames, as was the case with French warships and "are not fastened in any way to one another." Ollivier (*Ibid.*:66) added however,

> There appears with our [French] method to be a better fastening together ... yet with the English method there is an immense saving of timber, of ironwork, and of labour. ...yet it is proved by the success which accompanies [English] ships that in this fastening-together [the French] are excessive, and needlessly so. All the English ships, whether those of 100 guns or those of 20, keep the sea and last as long as do ours ....

Interestingly, Ollivier (Ibid.:69) suggests that in 1737 Woolwich Dockyard was still using whole-molding in some form in the construction of English warships.

Why was this building method so universally employed? The reasons were probably very simple: time would have been saved if only every third or fourth frame had to be fashioned by lofting and the bow and stern frames, always more difficult to determine from the lofted lines, could have been fashioned in place, using the ribbands as a guide; also, as Ollivier pointed out, timber and fasteners were also saved.

A twentieth-century Danish shipbuilder (Hasslöf 1972, quoted in Steffy 1991:8) summed up his description of properly forming a hull as follows:

> But once you've got over the bilge, the worst's over. Then you can put in the futtocks and raise the toptimbers. They can only go one way.

This straightforward statement probably reflects the general approach of builders for millennia; the fundamentals of ship design and construction can, in a sense, be distilled down to the best means of "getting over the bilge," thus forming the general shape of the hull. In earlier periods, when the concept of graphically projecting a ship's hull shape did not exist, there would have been no logical means for predetermining the shape of internal framing structure. Therefore, the builder had to rely on a developed ability to shape somewhat-pliable planks into the desired form, by "rack of eye," then insert strengthening members inside, as required.

Other Characteristic Framing Features

Other framing features that were extremely common in eighteenth century vessels were first futtocks offset from the keel and chock scarfs joining the futtocks. Hedderwick (*Ibid.*:265) says "...the first futtock should reach from within 4 or 6 inches of the keel, to 3, 4, or 5 feet above the floor-head, according as may be agreed upon in contract ...." Offsetting the first futtocks from the centerline was a very common practice over a relatively long time span, particularly in merchant vessel construction. According to Baker (1955:24-25), "In English merchant vessels this practice [offset first futtocks] continued well into the nineteenth century." There was apparently little concern among merchant builders that having the first futtocks unattached to each other or to the keel compromised the structural integrity of the hull. The practice was said to provide a larger volume in the bilge for water to collect, thus minimizing the possibility of water damage to the cargo. After 1715 the concern for strength caused the Admiralty to specify that English warships have their first futtocks brought over the keel and joined with a chock (Lavery 1984:32).

Ollivier (1737:209) also inspected Dutch shipyards and reported that Dutch framing was similar to that of the English, except their frames are not through-bolted. He adds that the success of the English and Dutch framing

> can leave no more room for doubt as to the needlessness of the iron bolts [the French] employ in fastening together the frame timbers of [their] ships.

Ollivier's statement is an apparent endorsement of English shipbuilding in general and, by inference, of English merchant shipbuilding, which continued the widespread practice of installing futtocks that were joined only to the planking and, usually, the ceiling.

An examination of the archaeological examples described in Chapters 6 and 7 will show that there was a very wide variation in the framing of eighteenth-century merchant vessels. Most had offset futtocks, most had mold frames and filling frames, and a wide variety of framing patterns was evident.

Hedderwick (*Ibid.*) also specified the use of chock scarfs to join the floors and futtocks. This technique was in common use in English warships, which Ollivier (1737:67) said is effective in reducing the amount of compass timber required for framing, since the chock scarf allowed bearding of futtocks to eliminate bad grain or sapwood. He also observed that iron knees were already being substituted for those made from compass timber (*Ibid.*:146).

Regardless of the lofting method employed, the typical image of a vessel "in frame" is of a fully-formed "skeleton" consisting of keel, stem, stern, transom, frames, keelson, deck beams and a few longitudinal plans or ribbands; the frames are generally closely spaced and fastened in pairs for strength and rigidity; all timbers are smooth and regular, with all faces squared and blemish-free; there is a "master couple" or midships bend just forward of the middle of the keel, and first futtocks forward of that point are fayed to the forward face of their irrespective floors, while aft, first futtocks are joined to the after side of their floors. Most contemporary models, especially Admiralty models, represent such a system. In actual practice, however, such regularity was rarely the case, at least with merchant vessels.

None of the above construction methods offers any indication of a major technological breakthrough during the eighteenth century. The examination of many more shipwrecks from this period will be required to establish clear evolutionary patterns. For now, it can at least be concluded that framing patterns, scantling size, room and space and fastenings all indicate that a wide variety of techniques, materials and methods in use for merchant ship construction throughout the century. It is very likely that the "mold frame and ribband" construction method, beautifully simple and efficient, was utilized almost universally by merchant shipwrights and that the method contributed significantly to the lower construction costs that made English vessels more competitive during this period.

Efficiency, Stability and Sailing Qualities

Steel (1805:181), writing just after the end of the eighteenth century, offered a very positive assessment of the stability and sailing qualities of English merchant vessels:

> Our merchant vessels have, in general, great stability ... and are, in this respect, equal to any vessels in the universe. ... Yet with the wind large, especially when blowing hard, their rate of sailing has frequently been found equal to [that of ships of war]; although, upon a wind, their inferiority may be very considerable.

There were similar statements in Charnock (1800-1802) and elsewhere, and various methods for computing center of gravity, metacenter and other terms relating to stability were discussed in various treatises on naval architecture, especially towards the end of the eighteenth century. However, none of the contemporary writers suggested that English merchant vessels exhibited any startlingly new characteristics that radically improved their efficiency, stability or sailing qualities. See Appendix F for more information.

Regional Design Influences and Variation

There were undoubtedly some very basic regional differences in the appearance and construction of eighteenth-century merchant vessels that would have been obvious to a knowledgeable observer However, most of those differences have been lost through the lack of adequate documentation and the passage of time. More research—both archival and archaeological—is needed to help fill the gaps that currently exist. We do know that the shipyards in the north of England, especially in such northeast ports as Whitby and Newcastle, were well respected for their sturdy, bluff-bowed colliers; we also know that most of the large East Indiamen continued to be built in the Thames region.

Although merchant vessels continued to be built throughout England, the northern yards dominated the English shipbuilding industry in the eighteenth century, and their vessels infused the English merchant marine with hundreds of strong, long-lived bulk cargo carriers. Even though these colliers are discussed in various sources, there are no distinct references to major differences between "north-country" vessels and any other full-bodied merchant vessels, nor to improvements over time.

Summary: Portrait of a Typical English Merchant Vessel from the Eighteenth Century

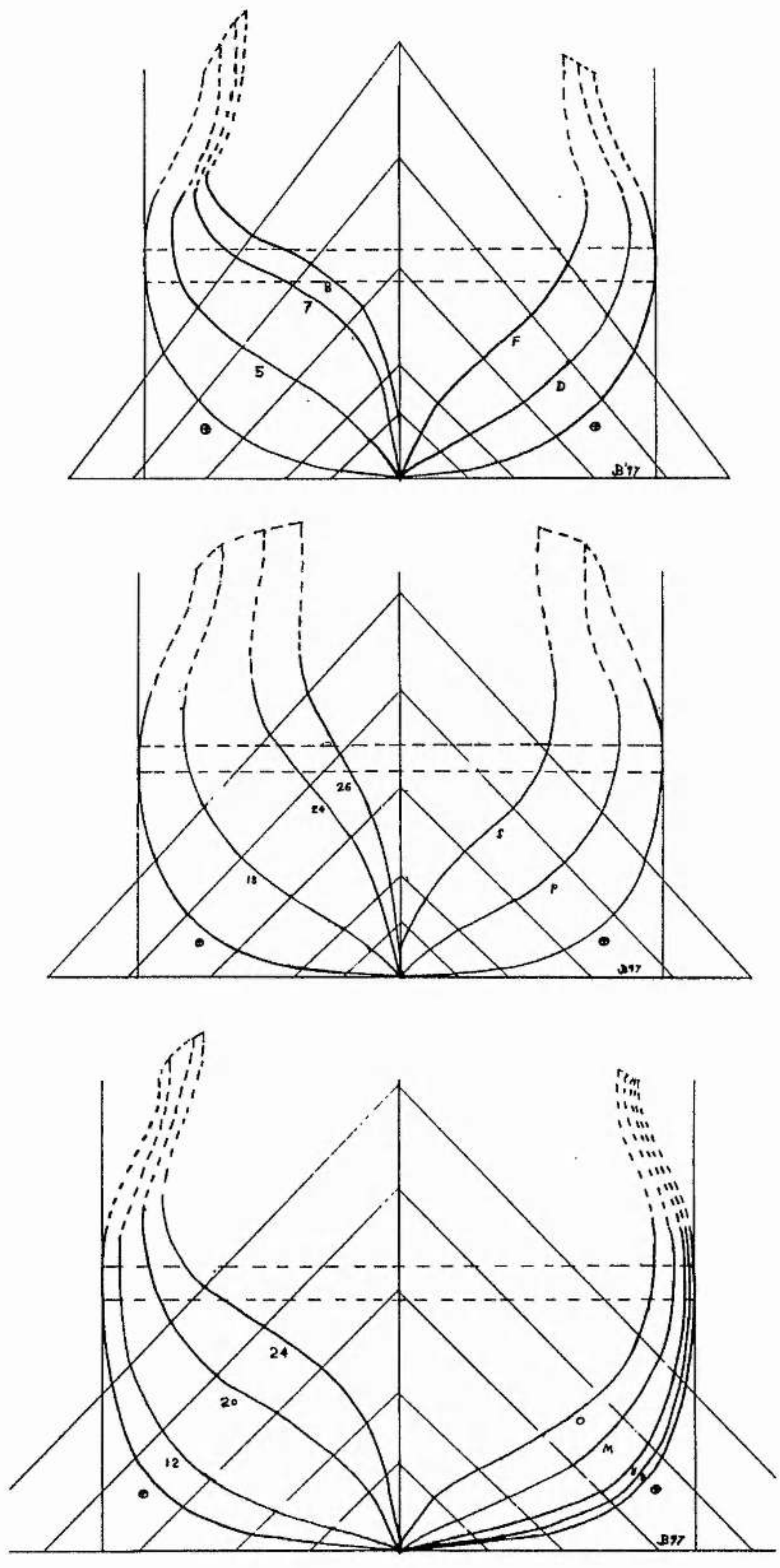
This study has presented descriptions, illustrations and draughts of a variety of eighteenth-century English merchant vessels; in addition, a number of archaeological examples have been described and illustrated. The examples demonstrate a richly diverse range of hull forms and rigs that existed during that time period. Throughout the century different treatises described the "ideal" hull form; however, those, too, exhibited a wide range in concept and form. This section identifies similarities and patterns that help define a "typical" English merchant vessel from the eighteenth century.

Hull Form and Vessel Class

As previously discussed, eighteenth-century merchant vessels apparently were grouped by their contemporaries into broad, general categories based upon their hull form, usage and, later, type of rig. Data examined during the present study suggests that few shipwrecks can be accurately placed into one of these "classes" based on hull remains alone. In fact, a skilled eye is required even to identify a vessel type or class depicted in a draught, drawing or painting. However, a few general characteristics of hull form can be associated fairly confidently with merchant vessels from the period of interest.

Mungo Murray (1754, 1765) offered a method of constructing the body plan for a variety of vessels from a series of offset tables based on diagonals. Figure 8.9 illustrates three of Murray's vessels, constructed from his tables. The first is the ship *Thames*, 340 tons; the next is a pink, *Bonetta*, 398 tons; and the last is the *London*, an East India ship of 630 tons. All three hull forms exhibit a fair amount of deadrise, slack, rounded bilges, and moderate tumblehome. The first two vessels are not designed for maximum cargo capacity, but the *London* is very capacious.

The *Betsy*, a north-country collier brig (See Chapters 5 and 6) exhibits a reconstructed body plan not unlike those recommended by Murray less than two decades before the *Betsy* was built (Figure 8.10). However, the *Betsy* did not have the hollow entrance



THAMES, ship,
340 tons

BONETTA, pink,
398 tons

LONDON,
East India Ship,
630 tons

Figure 8.9: A comparison of three vessels constructed from tables supplied in Mungo Murray's Treatise on Ship-Building *of 1754 (J. Broadwater).*

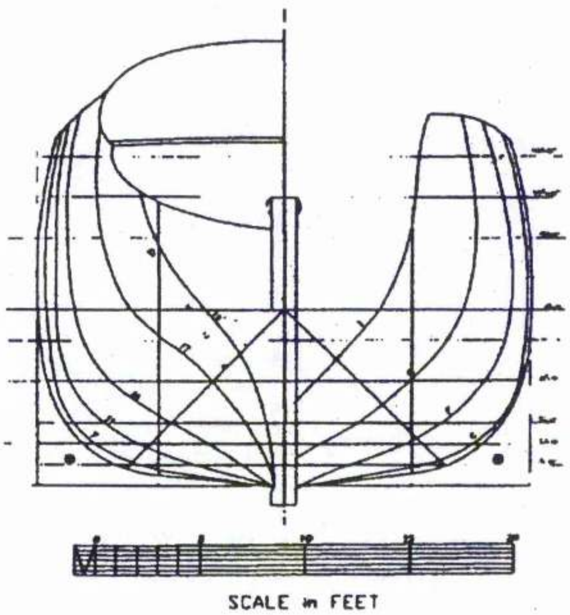


Figure 8.10. Reconstructed body plan of the Betsy, *1772 (John D. Broadwater).*

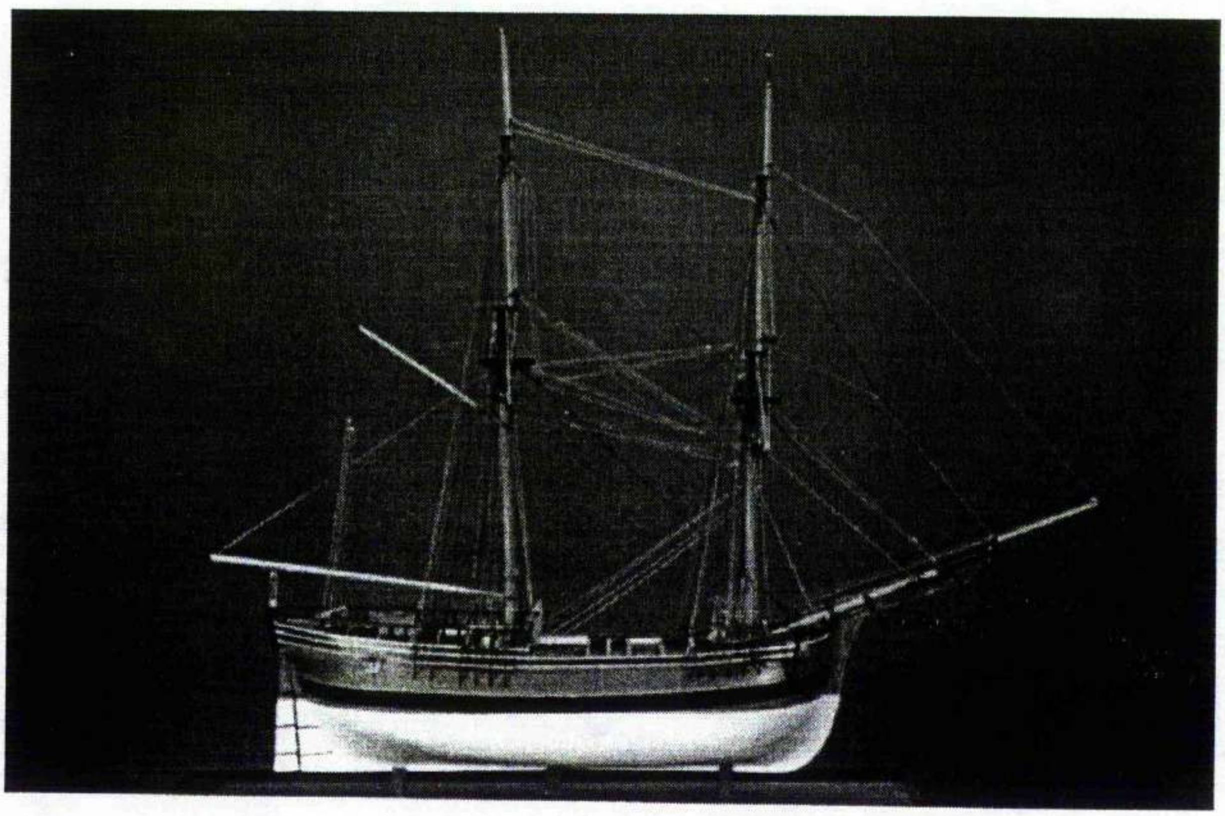


Figure 8.11. Scale model of the Whitehaven collier Betsy, *1772 (courtesy Jamestown-Yorktown Foundation).*

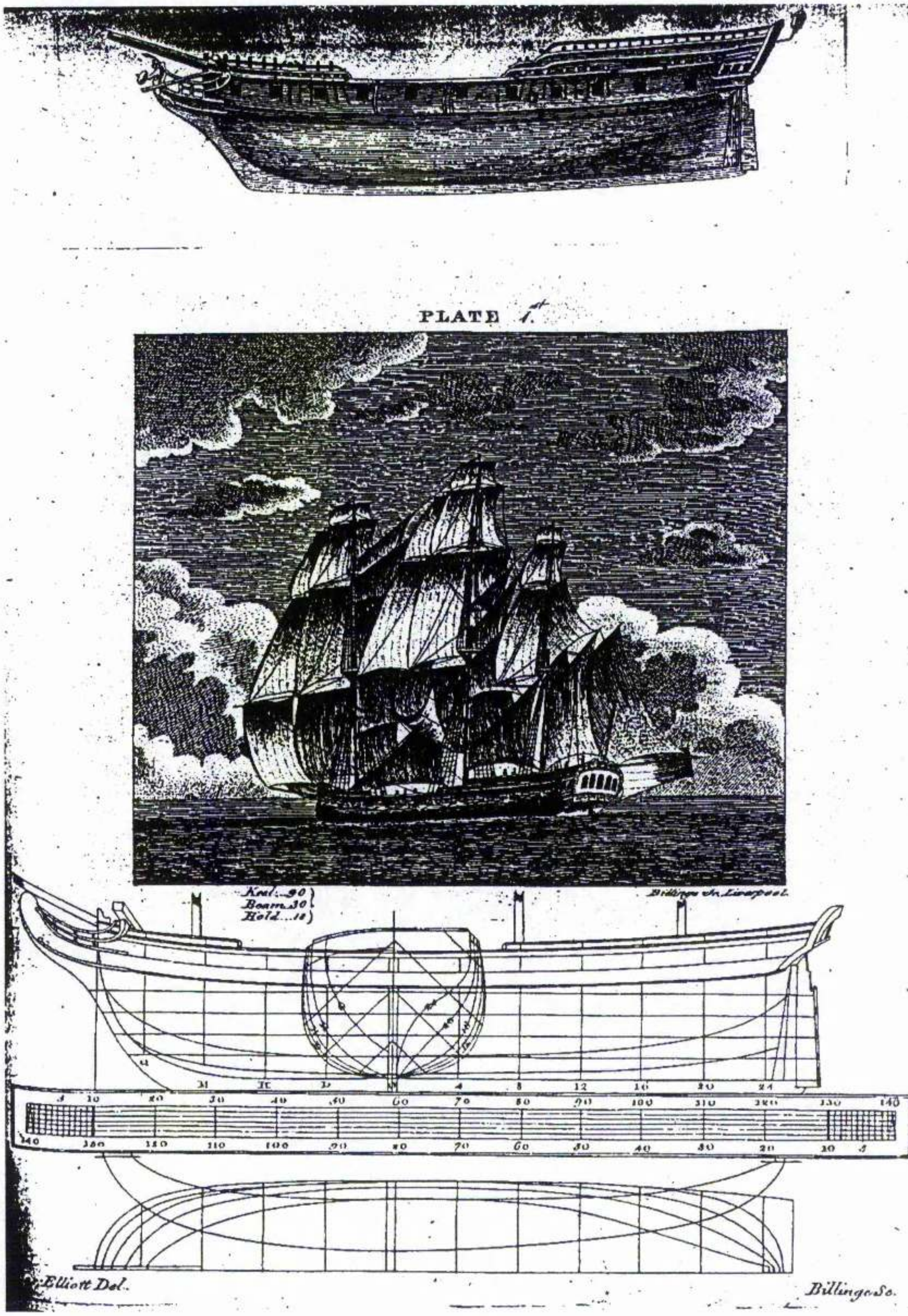


Figure 8.12. William Hutchinson's illustration of the Hall, *a "typical" merchant vessel from the late eighteenth century. (Hutchinson 1794:Plate 1).*

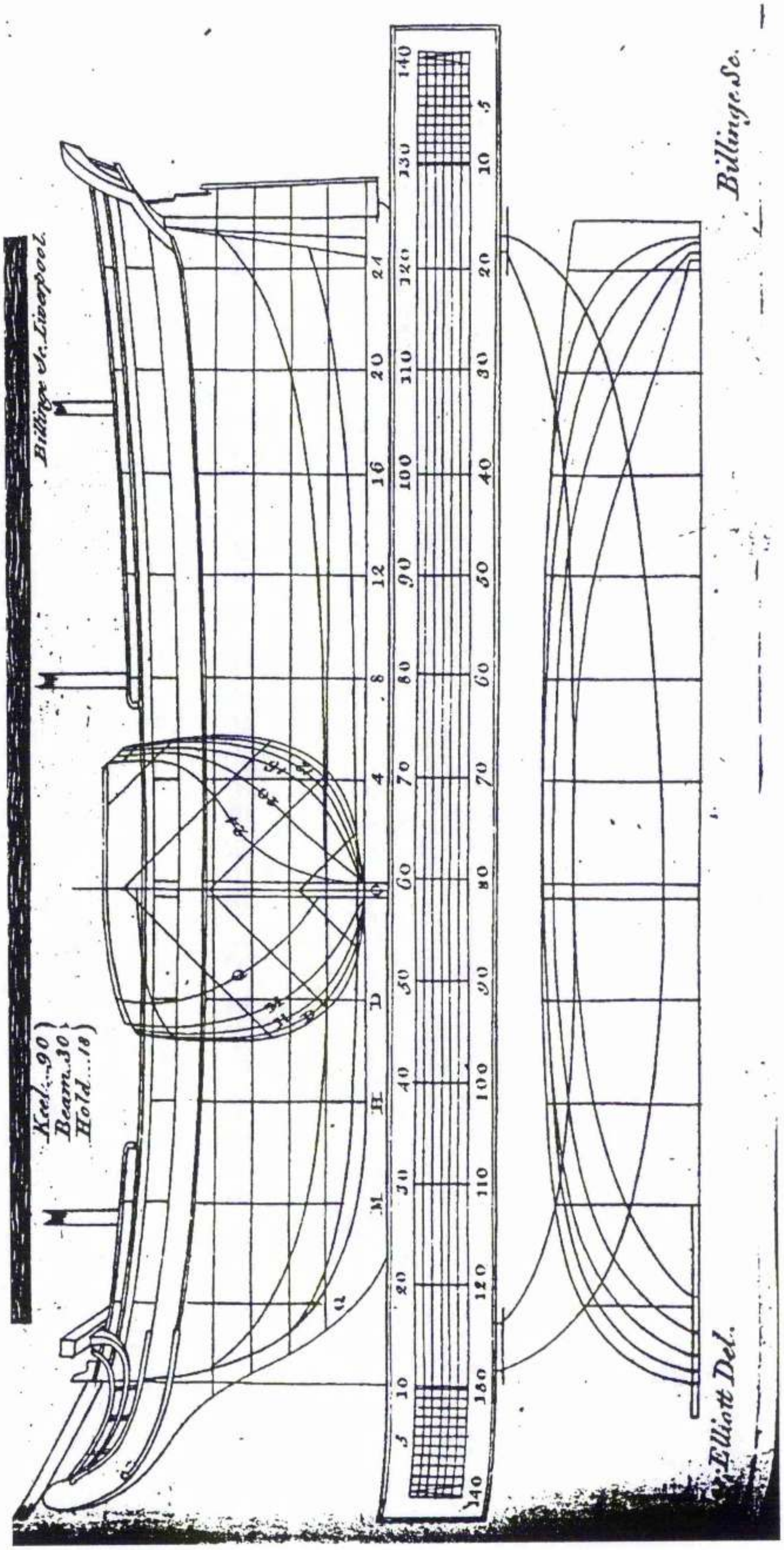


Figure 8.13. Enlarged view of William Hutchinson's illustration of the Hall, *a "typical" merchant vessel from the late eighteenth century (Hutchinson 1794:Plate 1).*

exhibited by most of Murray's vessels. The *Betsy* is drawn with very little tumblehome, similar to other contemporary colliers, but the hull above the load waterline is speculative, as that portion of the hull was not preserved. The *Betsy*'s form is well illustrated in the photograph of an accurate scale model (Figure 8.11).

In 1794, William Hutchinson, of Liverpool, published *A Treatise on Naval Architecture ... of Merchant Ships in general ...* in which he illustrated a single merchant ship (1794:Plate 1). This vessel was probably the *Hall*, a three-deck ship of 375 tons burthen, built in 1785 to Hutchninson's design (Stewart-Brown 1932:29). Hutchinson considered the *Hall* to represent the desirable attributes to be sought in a merchant vessel (See Figure 8.12). His lines plan (enlarged in Figure 8.13) shows a hull with a full form, a parallel midbody beginning at the master couple, moderate deadrise, very rounded bilges, convex entrance (no hollow), slight tumblehome, considerable rake to the stem and a full head. In general hull form, Hutchinson's merchant ship is also very similar to that of colliers such as the *Betsy*. It seems reasonable to accept Hutchinson's opinion that the *Hall* has a general hull form and rig that is typical of English merchant vessels from the late eighteenth century.

It must be remembered, however that the *Hall* was large and heavily armed for her day; few contemporary merchant ships would have had three decks, including a full gun deck. The liverpool merchant ship *Mersey* (Figure 8.14), with her simple, unadorned lines, plain head and square stern is probably more typical of English merchant vessels employed in the coastal, Baltic and West Indian trades.

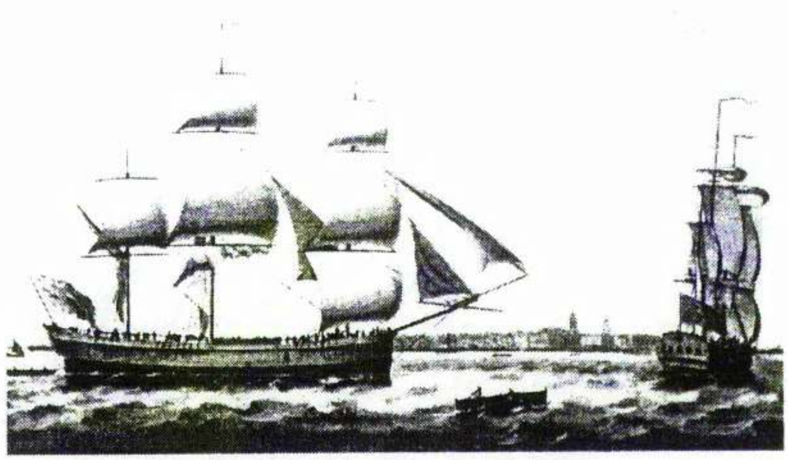


Figure 8.14. The Liverpool merchant ship Mersey *in the Thames, 1776 (Oil painting by Francis Holman).*

The graphs shown in Figures 8.15 and 8.16 provide a general guide to the dimensions of merchant vessels. The graphs, based on data from a variety of lines plans, permit the determination of breadth and tonnage for a vessel of any given length between perpendiculars. (Inversely, given breadth or tonnage, a length can be determined.) The length-to-breadth ratio can be estimated by a similar method, using Figure 8.17. Additional data and graphs are included in Appendices C through J.

Rigs and Sail Plans

In the engraving of the ship under sail, Hutchinson's *Hall* is shown with a large spread of canvas, including studding sails, staysails, and royals. Clearly, not all merchant vessels were so rigged; however, contemporary sources leave no doubt that merchant vessels often carried a relatively large sail area. This fact is not surprising, since the heavy loads and high hydrostatic resistance of most merchant vessels required a significant driving force.

Figure 8.18 and Table 8.1 provide general information on the locations of masts for various types of rig. Additional information on mast locations and mast and spar dimensions and proportions is included in Appendix E.

Merchant Vessel Evolution

This study has revealed no radical evolutionary pattern among eighteenth-century merchant vessels. Archival documents, nautical treatises and archaeological data all suggest at least one general conclusion: the eighteenth century was a period encompassing almost every type of theory and practice in naval architecture. The seventeenth century had seen the formulation and publication of early theories on ship design and the development of lines plans. Although those early design theories were put into practice in some European naval shipyards, they remained virtually unknown to merchant builders. By the nineteenth century, the use of plans in the construction of naval and merchant vessels had become almost universal; naval vessels—although not merchant vessels—were fully stan-

Figure 8.15
Curve for Determining Tonnage or Length

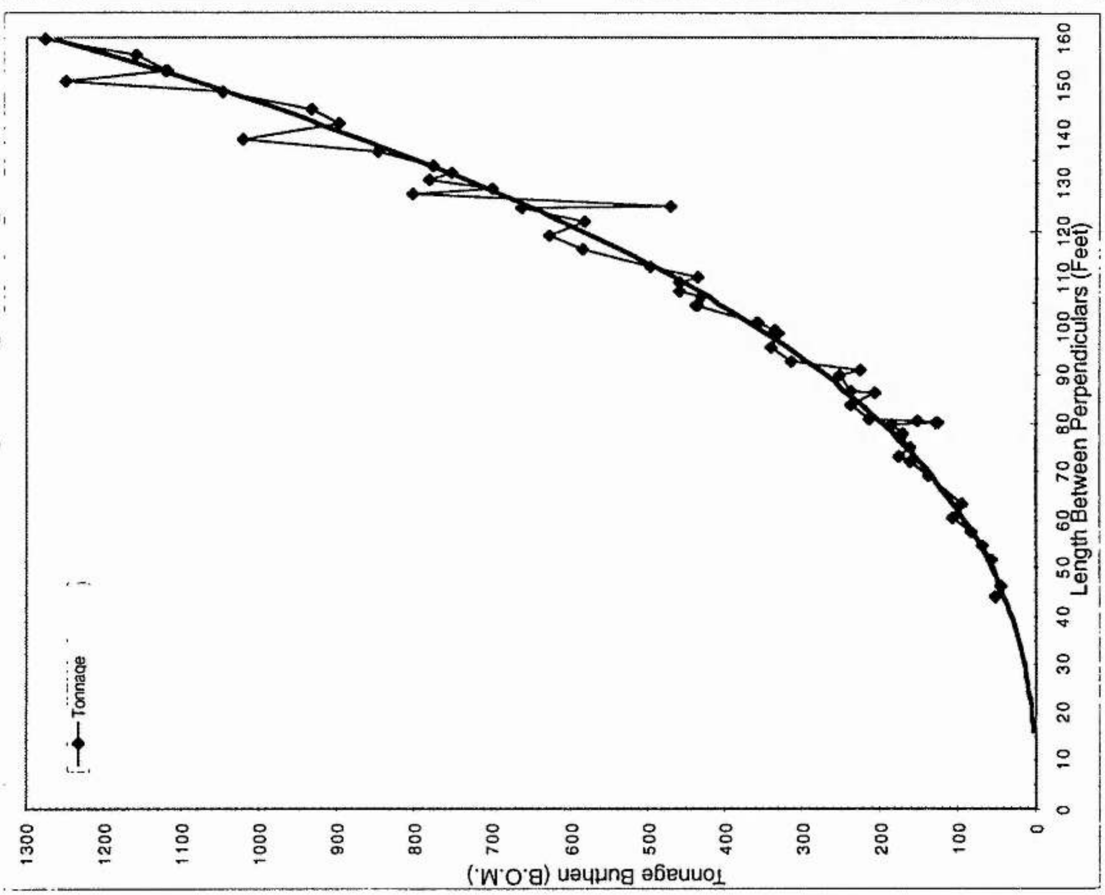


Figure 8.16
Curve for Determining Breadth or Length

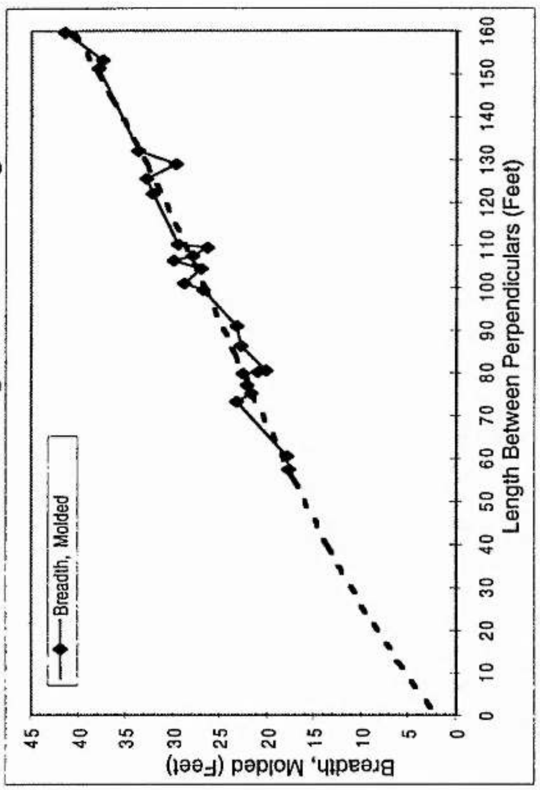
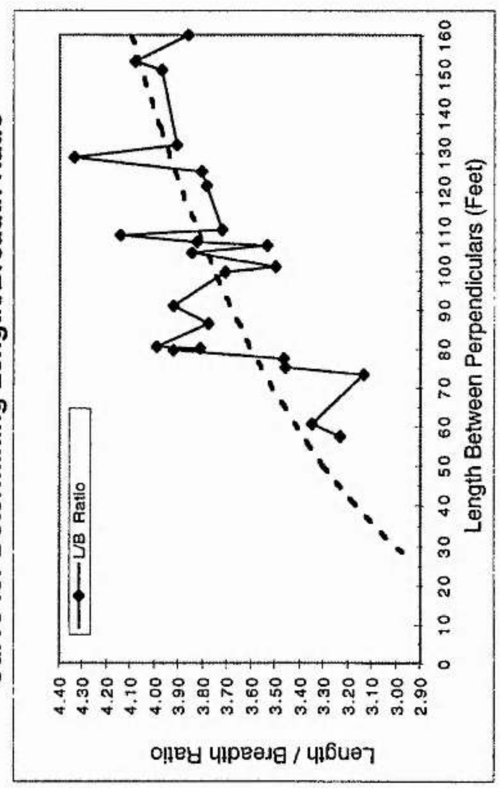


Figure 8.17
Curve for Determining Length/Breadth Ratio



DATA FROM A WIDE RANGE OF 18TH/C VESSELS

Figure 8.18

MAST AND MIDSHIP FRAME POSITIONS FOR FOUR TYPES OF RIG

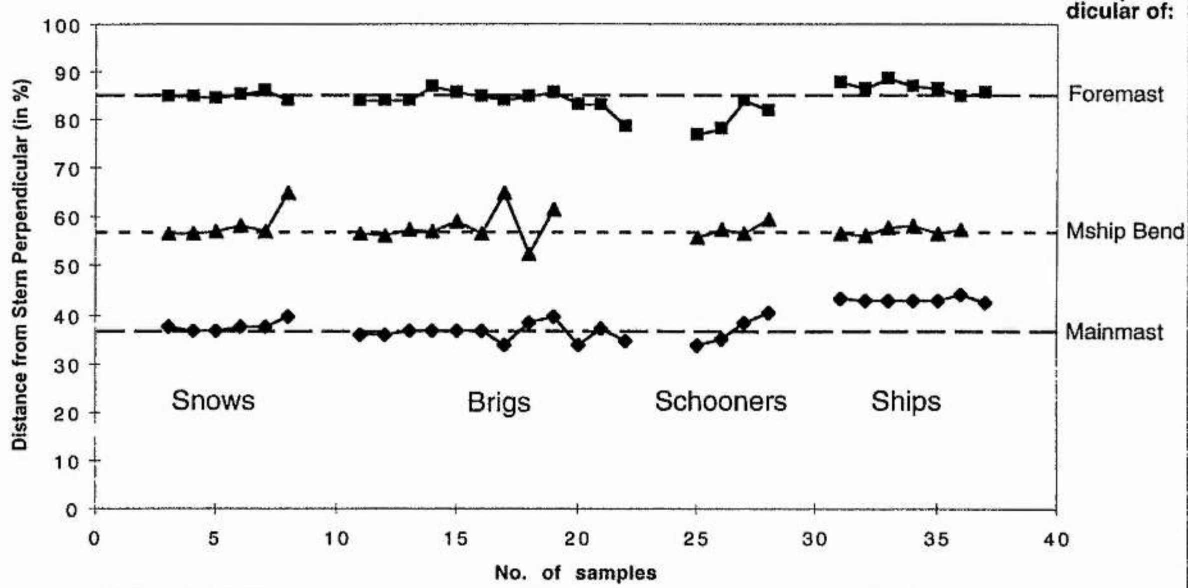


TABLE 8.1
Average Mast Positions For A Variety Of Vessel Types

VESSEL TYPE	BURTHEN (TONS)	DIST. FROM STERN PERPENDICULAR (IN %) MAINMAST	FOREMAST	MIDSHIP BEND
SNOWS (CHAPMAN)	253.9	37.5	85.2	57.3
(MACGREGOR)	137.0	39.7	84.4	65.2
BRIGS (CHAPMAN)	154.0	36.6	85.2	57.4
(MACGREGOR)	176.3	37.4	85.1	59.9
(DAVIS)		35.5	81.9	
SCHOONERS (CHAPMAN)	154.8	34.7	77.8	56.9
(MACGREGOR)	119.0	39.6	83.2	58.2
SHIPS (CHAPMAN)	345.6	43.4	87.7	57.5
(MACGREGOR)	317.5	43.7	85.8	57.2
(DAVIS, 1-4-6)		42.9	85.7	
SHIPWRECK 44YO88	180.0	41.4	85.3	60.2?

dardized, both in terms of design and construction. The eighteenth century, however, was a period of transition, with many diverse geographical and political factors affecting the patterns of diffusion of new theories and practices.

The data do, however, suggest a few general evolutionary trends among English merchant vessels during the eighteenth century. Vessels tended to get longer in relation to their beam, even though the colliers remained very beamy. The trend towards larger two-masted vessels continued throughout the century, with brigs, brigantines and snows often exceeding 200 tons burthen. The average size vessel was still quite small—less than 200 tons right through the end of the century. Rigs became simpler, reducing the number of men required for sail handling. Fore-and-aft sails were incorporated into most vessels in the form of staysails and, especially, headsails, giving vessels an ability to sail closer to the wind. The move towards wider utilization of fore-and-aft sails also led to a rapid increase in the number of schooners being built and employed in a wide range of mercantile trades. Better mechanical equipment, including improved capstans, pumps, rigging and, on larger vessels, the steering wheel, reduced labor requirements. Vessels tended to travel in convoys, thus reducing the need to carry armament; this further reduced manning requirements and made merchant vessels more cost-effective (Bosscher 1995:24-32; MacGregor 1985:12-14, 29-43, 64-80; McGowan 1980:23-40).

Charnock (1800-1802), Steel (1805) and others supported the general impression that English merchant vessels during the eighteenth century were competent and durable. However, none of the contemporary writers made the claim that English shipyards produced a new, improved vessel type during the eighteenth century; certainly, no new vessel type is named in any of the writings examined during this study. Therefore, with no supporting evidence to be found, it must be concluded that the eighteenth century was a period of gradual improvement in English merchant vessel design and construction, punctuated by no radical changes in form or function.

Likewise, the present study found no compelling evidence for the hypothesis suggested by Davis (1962:71) and supported by McGowan (1981:56) that eighteenth-century

English merchant vessels were adapted from seventeenth-century Dutch *fluyts*. Much has been written about the proliferation of the "North Country Cat" (McGowan 1981:56), which was supposedly the English adaptation of the *fluyt*. However, evidence from this study indicates that the cat-built merchant barks and brigs were far less numerous than were square-sterned vessels that were quite different than *fluyts*. *Fluyts* (Figure 8.19) were lightly-built vessels with lofty, round sterns, broad buttocks and a high length-to-breadth ratio (4:1 to 6:1) (Steel 1780; Unger 1978:37). Eighteenth-century English merchant vessels, on the other hand, were beamy and heavily built, and the vast majority were square-sterned. *Fluyts* were very flat-floored, with a relatively hard chine and considerable tumblehome, whereas the body plans of English merchant vessels (e.g., Figures 8.9, 8.10 and 8.13) exhibit slight deadrise and a very slack, rounded bilge and little or no tumblehome. It may eventually be shown that the evolution of English merchant vessels in the eighteenth century owed more to Scandinavian influence than to Dutch. Danish timber barks (Figure 8.20) were extremely boxy and bluff-bowed, well suited to bulk cargoes. Therefore, it must be concluded that English merchant vessels evolved steadily throughout the eighteenth century by drawing from a wide variety of designs and hull forms, with a large percentage of them, especially the bulk cargo carriers, taking the general shape of the "north-country collier."

In fact, if there was, indeed, an improved vessel type in England during the eighteenth century, then the "north-country collier" was surely it. There is much evidence to suggest that the highest quality, most capacious, most efficient, strongest,

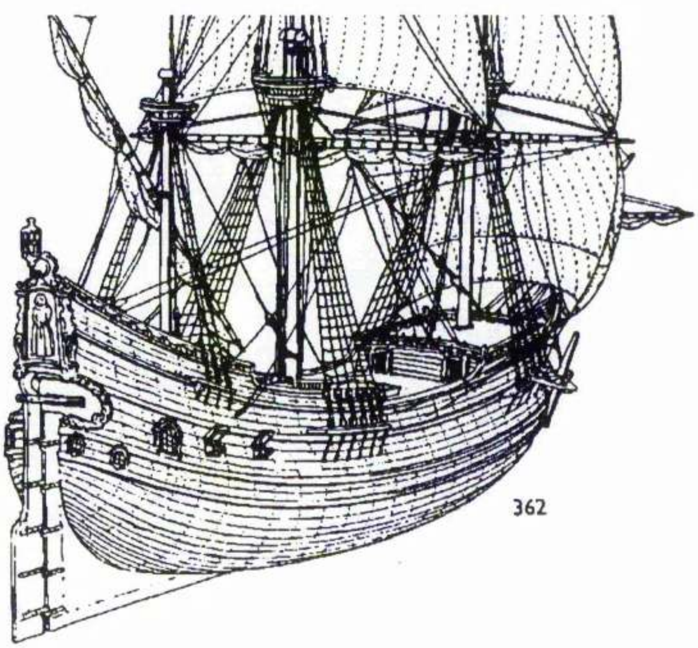
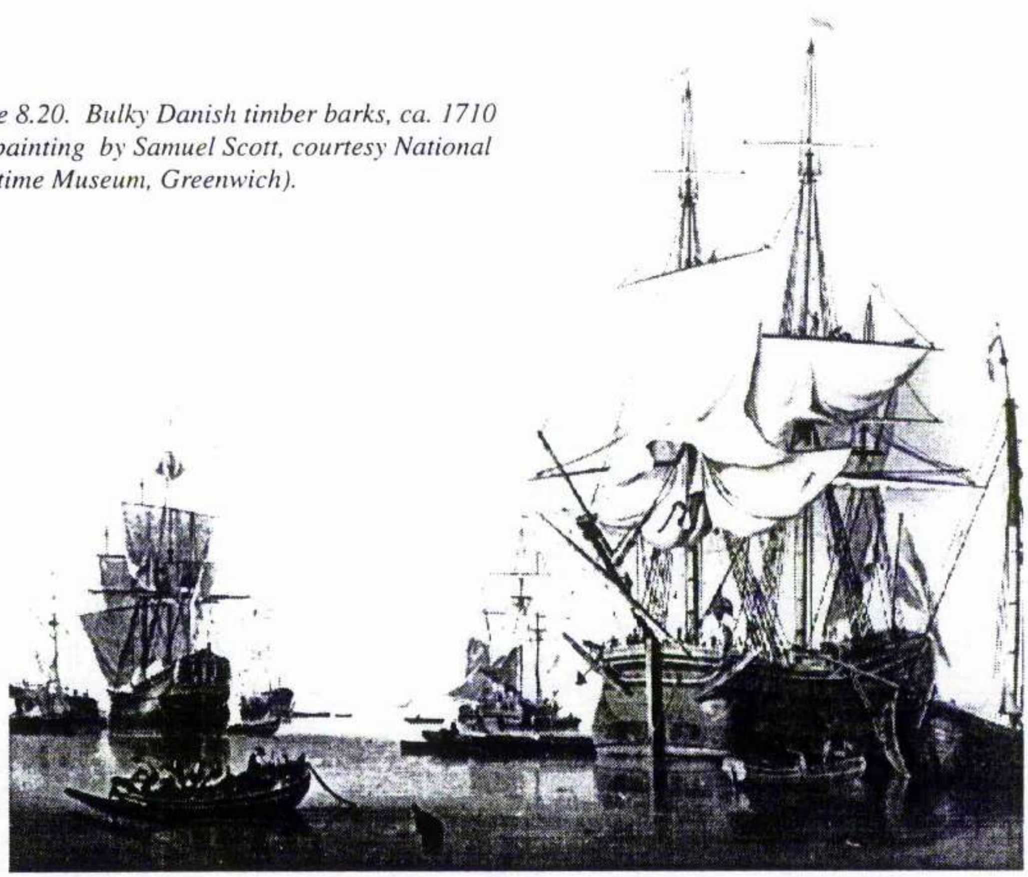


Figure 8.19. Dutch fluyt, 16th-17th century, showing high, round stern (Landstrom 1961:Figure 262).

longest lasting and most stable merchant vessels in England during the eighteenth century were being produced in the northern ports where the primary export was coal. Colliers were so common along the coast, especially between the Tyne and the Thames, that they became a familiar sight and were easily recognized. It is likely that the term "collier" became almost a generic term for a full-bodied merchant vessel, no matter what its cargo.

Rather than representing a radical new design, the collier appears to embody the best compromise of qualities for a bulk cargo carrier, qualities that were already known and appreciated a century earlier, but which may have found a new harmony in the collier. Primarily designed for relatively short coastal voyages, the colliers proved themselves fully capable of navigating the oceans of any part of the globe. Colliers transported Captain James Cook and his party on three voyages of exploration, a collier carried Captain William Bligh on his ill-fated voyage to Tahiti, and colliers by the score supported the efforts of the

Figure 8.20. Bulky Danish timber barks, ca. 1710 (Oil painting by Samuel Scott, courtesy National Maritime Museum, Greenwich).



Royal Navy and the British Army on several continents over the course of numerous wars. The Whitehaven collier brig *Betsy* (Figure 8.21) examined in detail in this study, is representative of this class or type.

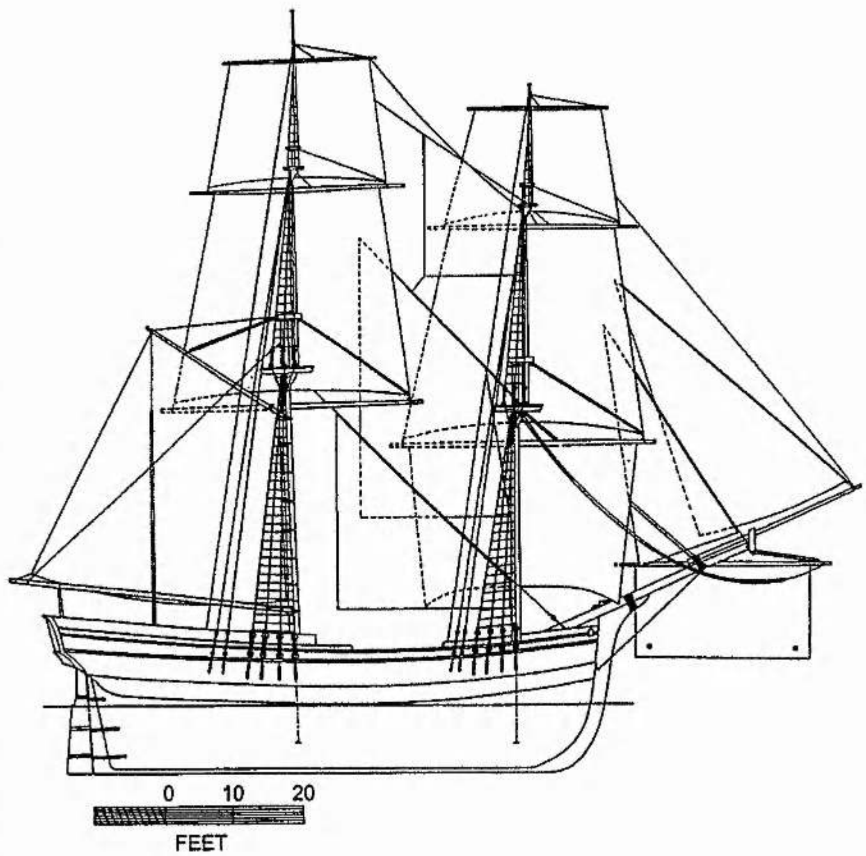


Figure 8.21. Collier Brig Betsy *of Whitehaven, 1772 (John Broadwater).*

It must also be asked, did the collier emerge in northern England as a direct result of economic pressure for a more efficient, economical and reliable means of transporting goods, or did technological advances produce an improved merchant vessel which resulted in increased profitability for merchant shippers and a corresponding growth in the English merchant marine? This question seems to have no simple answer. The most likely answer, as is often the case, is that each factor influenced the other. Another, related, question remains to be considered: why was there a shift in shipbuilding from the Thames and East Anglia to the northern ports? Undoubtedly there were several interrelated factors, but the principal factor was probably economic. The coal merchants in the north had a growing need for sturdy bulk carriers to transport their coal to market. They probably encouraged the building of vessels in local yards, taking advantage of ample supplies of suitable timber and cheaper labor than was available in the Thames yards. It appears that when local shipwrights proved their readiness and ability to meet the challenge, the rapid growth of northern shipbuilding began.

Even with the many descriptions and widespread praise focused on the flat-floored, apple-bowed colliers of northern England, there does not appear to be sufficient evidence to assert that English colliers represented, in the eighteenth century, a radically improved vessel type. However, it seems reasonable to assume that those sturdy, reliable vessels successfully satisfied the economic needs of the times and provided a new source of pride for English shipbuilders. It also seems reasonable to speculate, in retrospect, that their appearance, in the large numbers that flowed out of northern yards in the eighteenth century, improved the overall efficiency and quality of the English merchant marine and validated the skill and adaptability of their builders.

Suggestions for Future Research

With so many questions still unanswered and with the image of eighteenth-century merchant vessels remaining so dim, there is every reason to hope that the present study will be continued and expanded through additional scholarly research. The story of the Betsy is not yet complete, and just as this thesis was being printed, the author made contact with the Younghusband family, whose ancestors built and sailed the *Betsy* and other colliers during the eighteenth century. The Younghusband family is still in possession of a family Bible and an assortment of letters and papers relating to the eighteenth-century Younghusbands of Whitehaven, and the family is anxious to share their information with the author in return for more information on the *Betsy*. This research will be pursued as soon as possible, with the expectation of gaining new, useful information on the construction of the *Betsy* and other contemporary merchant vessels.

Although more information will certainly be gleaned from documentary sources, the best source of additional information on eighteenth century merchant vessels will continue to come from archaeological sites. Data is still being processed from such sites as the

Slufter collier, the *General Carleton* of Whitby, the Bermuda merchant vessel and others; and new sites are being discovered. As more relevant sites are excavated, documented, analyzed and published, the database on these vessels will grow until, finally, sufficient information will be available for the development of a much more complete picture of the construction and evolution of these important but unheralded commercial carriers of the eighteenth-century English merchant marine.

Notes on Chapter 8

[1] The Yassi Ada wreck dating to the seventh century showed evidence of an early attempt at attaching upper plans to pre-installed futtocks (Steffy 1991:1).

[2] However, fully-developed lines plans were yet in the future.

APPENDICES

APPENDIX A

A Discussion of Tonnage Measurements

Carrying capacity has been, throughout the ages, possibly the most significant attribute of merchant vessels, yet few terms have been so misunderstood, misinterpreted and even misused. Lyman (1945:I:223) succinctly defined the problem when he wrote,

> The topic of tonnage of vessels is one in which an appalling amount of misinformation is current, even among those rather closely connected with maritime affairs. ... A statement of the tonnage of a particular vessel is an essential part of her description, but it is subject to misinterpretation unless it is accompanied by an understanding of the way in which it is derived.

Similarly, William Salisbury (1966a:41) opened his five-part series on tonnage in the *Mariner's Mirror* with this statement:

> The subject of tonnage measurement has always been productive of argument ... and the most casual inquiry into maritime records will show how frequently the figures given by equally authoritative sources for the same ship will differ in detail for no apparent reason. In modern times ... there has been a general failure to appreciate that there is rarely any direct connexion between the different formulae or rules, and that each individual example must be studied in its own context.

As recently as 1933 the *Journal of Commerce* felt it necessary to publish an entire volume on the subject of tonnage. In that book, *Hints on the Register Tonnage of Merchant Ships*, the author (Blocksidge 1933:1) states in his introduction,

> Tonnage regulations have made progress through the experience of many years; but their application to the measurement of modern merchant ships has become very difficult of interpretation, and perplexing to everyone associated with the operation of ships.

Charnock, in his *History of Marine Architecture* (1800-02:II:483 [fn]), laments on the poor quality of tonnage estimations during the seventeenth century as follows,

> The mode of calculating the tonnage of ships appears to have been managed during the greater part of [the seventeenth] century much more indeterminately than can readily be credited. ... The same variation takes place almost uniformly through all the ships of the navy, and fully proves, that the calculations alluded to were founded on little more than mere supposition.

As an example, Charnock cites the following tonnages for the *Royal Sovereign*, from the Navy lists:

calculated at launch -	1637 tons burthen;
list of 1651 -	1141 tons;
list of 1654 -	1556 tons.

Later in his *History* Charnock (1800-02:III:340) states that because of the different shapes of ships' hulls "it is impossible a true measurement ever can be made; and ... no certain method will ever be discovered of obtaining the true capacity of vessels ..." until they are built more alike.

Blocksidge (1933:1) tells us that the Chinese had developed a method of tonnage assessment long before the Christian era and that by about the year 1254 A.D. the Swedish had established the *last* (estimated at about 4400 pounds) as the standard unit of measurement for carrying capacity. The term was still in use when Chapman published his monumental treatise and plates in the latter half of the eighteenth century (Chapman 1768, 1775). In England, probably in the fifteenth century, carrying capacity commonly came to be expressed in terms of the number of wine barrels—"tonneaux," hence the term "tuns"—a ship could stow in its hold (Blocksidge 1933:2).

Salisbury (1966a:41) argued that tonnage measurements evolved in response to the needs of merchant shipping. He further speculates that the customary wine container, the 'tun,' was an obvious measurement choice in England, since the wine trade involved almost all countries and most of the best ships at one time or another. Salisbury found evidence that at least by the middle of the fourteenth century ships were commonly referred to by the number of wine tuns they could carry, and a custom rapidly developed for equating other kinds of goods to the new general unit of the wine tun (*Ibid.*:42).

By the late seventeenth century shipbuilders, especially on the Thames, had developed very sophisticated formulae for computing the weight of cargo a ship could carry, based on the vessel's dimensions and hull shape (Blocksidge 1933:3). Around 1628 the

Royal Navy, according to Lyman (1945:I:225), adopted the tonnage rule T = (KxBxD)/100, where **K** is keel length, **B** is extreme breadth and **D** is depth. However, he added that

> For the hire of merchant vessels by the naval service the burden so found was increased by one-third (or one-fourth) to give 'tons and tonnage' on which the fees were based.

Lyman (*Ibid.*) further stated that in 1677 the Royal Navy adopted the formula [(L-3/5B)xBx1/2B]/94, where **L**, overall length or length on the main deck, was substituted for keel length. This formula was much easier to apply to a loaded vessel that was still in the water. By at least as early as 1626 the River shipwrights near London were already using 94 as the divisor in their tonnage formula (Salisbury 1959:83). (The computation of tonnage is discussed below in more detail.)

However, the first Act of Parliament relating to tonnage measurements was not passed until 1694, and the regulations were not applied to all merchant ships until 1773 (Blocksidge 1933:4). This Act persisted, with slight revision, until 1854, when the first Merchant Shipping Act was passed, introducing a new, and much-improved, method of computing tonnage (*Ibid.*).

The ambiguity concerning tonnage measurements became even a more serious problem in the eighteenth century when England, having enacted laws specifying a method for computing tonnage, found that the official method was not being utilized or was being improperly applied. Eighteenth-century accounts of discrepancies concerning carrying capacity has caused significant confusion among modern historians. A prime example is the misinterpretation of the Royal Navy's policy regarding the measurement of vessels to be leased as transports. A prominent historian accused the Navy Board of altering the accepted tonnage formula, reducing by approximately one-fifth the amount of freight it was obliged to pay for each vessel (Syrett 1970:112). This misinterpretation has been propagated by other historians and presented as an example of the unfair advantage taken of merchant shipowners by the government. In fact, however, the Navy Board was utilizing essentially the standard formula of the day and, therefore, was paying market rates for its shipping.

The misinterpretation is easily understood when the relevant documents are examined; they strongly imply at first glance that the Navy Board had invented its own formula for the computation of tonnage. However, several eighteenth-century naval architectural treatises describe the method to be used in computing tonnage burthen for vessels being hired for the Transport Service. All demonstrate more or less the same formula—the formula in general usage— and that formula deducts $^3/_5$ the beam from overall length to establish the length of the keel for tonnage determination (Salisbury 1966b:176-180).

The source of the problem is clear: most historians and many nautical archaeologists lack the depth of knowledge of early naval architecture that is required for analyzing the vessels under study. It is essential that such researchers collaborate with a trained naval architect or ship reconstructor, preferably one familiar with vessels from the time period under study.

Let us now attempt to summarize the key elements of carrying capacity, especially as they relate to eighteenth-century merchant vessels. Without discussing the evolution of tonnage formulae, which are well covered elsewhere (Blocksidge 1933; Salisbury 1966a, b, c, 1967, 1968a), let us accept from a wide source of documents that the term for carrying capacity used most widely in the eighteenth century was tonnage burthen, which was generally calculated from the formula

$$\text{Tons burthen (T)} = \frac{L \times B \times (B/2)}{94}$$

$$= \frac{L \times B^2}{188}$$

where **L** is length on keel for tonnage and **B** is extreme breadth. Extreme breadth was understood to be the width of the ship at its widest point, measured to the outer edge of the outer planking.

It is important to note that *depth* was not used in computing tonnage during the eighteenth century. This is presumably for practical reasons. The depth in hold was often difficult to determine due to the presence of cargo, stores and ballast; therefore, it was expedient to substitute one-half the beam which was, on a typical vessel, sufficiently accurate. Determination of the appropriate keel length was difficult and has been the cause of much of the confusion about tonnage determination through the years. Instead of attempting to actually measure the length of the keel (often impossible, as the vessel was generally afloat), the length was generally estimated by subtracting three-fifths of the extreme breadth from the length of the vessel at the lower deck, this being done to account for the rake of the stem and stern posts. It was this conventional adjustment to keel length ($L - {}^3/_5B$) that has caused some researchers to assume that actual keel length was being diminished for purposes of reducing lease rates. As verified by eighteenth-century sources, however, such was not the case (Sutherland 1755: 71; Steel 1805: 120; ADM 106), and we must completely vindicate the Navy Board.

Keel length continued to be the most uncertain dimension in the formula, and often resulted in wide variation in tonnage calculations for the same vessel. Various shortcuts were taken in determining length on keel for vessels in the water, as opposed to those in dry dock. The term could refer to actual length on the keel, from sternpost to stem scarph (keel "tread"); length between perpendiculars, those perpendiculars extended from the junction between the lower (or gun) deck and the stem and stern; length between perpendiculars, where the perpendiculars were extended from the underside of the transom, aft, and the hawse pipes, forward; or another length as defined by the particular builder, owner or surveyor. The other shortcut in the formula was approximating the depth of the hold as one-half the breadth. As with keel length, this was done for convenience, the measurement of depth usually being complicated by the presence of decks, equipment and cargo. Other practices may have affected the determination of tonnage for warships, which would have been the more familiar type in Royal Dockyards. It is no wonder that confusion was prevalent.

To further complicate matters, there was a difficulty in applying the tonnage formula to vessels carrying certain cargos. Most cargoes are, relatively speaking, light in nature and, therefore, most tonnage formulae were primarily concerned with volume rather than weight of cargo. Cargoes of stone or minerals, however, would sink most vessels to a dangerous draft before their holds were full, thus creating a need to determine the actual weight of cargo that a vessel could safely carry. This was known as the "deadweight tonnage" of the vessel (Salisbury 1968a:69), and is closely related to "displacement tonnage." In England, this exception applied most frequently to colliers, coal being the most common deadweight cargo. As a result, the statutory measurement of the capacity of colliers has a much longer history than that of vessels in the wine or other trades (*Ibid.*). The most common terms were the "keel" and the "chaldron," both of which varied from one geographic region to another until finally fixed by law.

There were also rules used by shipwrights and merchants, but these were applied for various special purposes and the register tonnage, calculated by standard rules, remained the common denominator throughout the eighteenth century (Salisbury 1967:251-264).

To fully understand the confusion over eighteenth-century tonnage calculations, however, one must recognize from contemporary shipbuilding treatises and other sources that the principal disagreement was with the *validity* of the formula, not its application. Numerous treaties expounded on the fact that the "official" formula did not yield a true measure of carrying capacity. In several treatises calculations were made for particular vessels, using the standard formula, then the actual volumes of the vessels's cargo holds were determined from careful measurement and the differences were tabulated; then various alternate formulae were proposed (Sutherland 1755: 71; Steel 1805: 120). There is no reason to doubt the accuracy of the comparisons, as most of the sources seem to have obtained similar results. There is a simple explanation for the discrepancies: the standard formula was not concerned with arriving at a precise measure of carrying capacity (as was the desire expressed in the treatises) but, rather to establish a simple, repeatable method for obtaining a tonnage value for use by the government for purposes of registration, assessment and commerce. As Lyman (1945:II:325) so aptly phrased it,

> For the layman the most difficult thing to grasp about register tonnage is that it has nothing to do with weight.

Ville (1989:77) examined the records of the London shipowning firm of Michael Henley and Son. Of 72 Henley vessels engaged in the coal trade between 1775 and 1830 their average actual cargo tonnage exceeded their register tonnage by 45% with a standard deviation of 17% around this figure. Not a single vessel carried less than its register tonnage. McCucker derived a 33% difference between cargo and register tonnage in English colonial trades during the eighteenth century (*Ibid.*:79). Ville (Ibid.:77) provided a table of capacity versus vessel size, as follows:

Registered Tonnage	Cargo Tons > Registered Tons (In %)	No. Vessels
< 100	40	5
101-200	43	18
201-300	48	31
301-400	46	19
> 400	5	1

The vessels with the largest cargo-measurement differential came from the yards in northeast England, whose average differential was 54% (Ibid.:78).

The other difficulty in obtaining accurate tonnage values arose from the inaccuracies and inconsistencies introduced by surveyors. Most errors were undoubtedly honest mistakes or resulted from ineptness; however, others were likely intentional, intended to minimize the duties on particular vessels. Even today, obtaining a qualified surveyor is important in determining the capacity or displacement of a vessel.

The standard formula produces a value for tons burthen, or capacity in measured tons. In estimating capacity in dead-weight tons, one-third was added to the value for tons burthen and the dead-weight tonnage value was known as *tons and tonnage* (Salisbury 1959:83). The standard formula was almost certainly in widespread use in England throughout the eighteenth century, although Salisbury (Ibid.:84) states that as late as 1800 the shipwrights in northwest England "—isolated from other centres and probably following an old local custom—used a divisor of 95." This was certainly a small discrepancy and should have caused few problems.

The derivation of the value of 94 for the divisor in the tonnage formula has been discussed by experts, with various theories being proposed for its origin. Salisbury (*Ibid.*) suggests that the value was probably not magical and probably "had no inherent virtue or value in itself." He speculated that it produced a figure roughly agreeing with that found by experimentation, and that it was probably adopted for statutory purposes "purely because of its traditional employment on the Thames, the most important shipping centre" (*Ibid.*).

The adoption of a standard formula in the eighteenth century led to some noticeable changes in ship design, since it was quickly realized by merchants that they would pay less duty if registered tonnage could be reduced. They took advantage of the fact that depth was estimated as one-half the breadth. By building ships narrow, but deep, they could increase carrying capacity while reducing the registered tonnage. Although it is difficult to assess the overall effect of this practice on ship design in the eighteenth century, it is certainly evident in the hull shape of some vessels, particularly those in the East India Company and comments in contemporary treatises suggest that vessel stability and safety were compromised by this action (Hutchinson 1794).

* * * * * *

For purposes of this paper, all references to tonnage assume the use of the standard formula, above, which was given force of law by an Act of Parliament in 1773 and was in general use throughout most of the eighteenth century (Kemp 1976:876; Salisbury 1966c:339-340). This formula is often referred to as the Builder's Old Method [or Measure] (B.O.M.).

APPENDIX B

A Review of Early English Treatises on Shipbuilding

(presented in chronological order)

c. 1585: Matthew Baker, "Fragments of Early English Shipwrighty." This valuable manuscript has not been published in its entirety, although most of the illustrations can be found in published works. The original has been preserved in the Pepysian Library, Cambridge, and a complete photocopy and transcription can be examined at the National Maritime Museum, Greenwich. The treatise contains relatively little information on naval architecture and even less on merchant ships, but it is useful because of its early date.

c. 1608: Thomas Harriot's "notes on shipbuilding."[1] These notes, preserved in the British Library, are not complete but are valuable since they deal mostly with merchant ships of approximately 100 tons.

1644: Sir Henry Mainwaring, *The Sea-Man's Dictionary*.[5] Mainwaring apparently wrote the dictionary between 1620 and 1623 (Anderson (X (1924):55; Lavery 1988:9) . There were various editions and the dictionary contains useful information on early shipbuilding methods.

1664: Edmund Bushnell, *The Complete Shipwright*. This excellent book is "the first printed work in English dealing purely and simply with naval architecture (Anderson 1924:59). Although it is brief and its illustrations leave much to be desired, the treatise is clearly and concisely written. Bushnell describes in detail the designing of a ship of 60 feet on the keel, giving a sheer draught and midship section, along with notes on "laying off." The book, reprinted in 1716, claims to offer proportions actually used by experienced shipwrights.

1670: Sir Anthony Deane, "Doctrine of Naval Architecture."[6] The title page of this unpublished manuscript states that it was "written in the year 1670 at the instance of Samuel Pepys Esq." Although not actually published until more than three centuries later (Lavery 1981), Deane's treatise was known by his contemporaries. Deane's *Doctrine* and Bushnell's *Treatise* together provide a relatively clear picture of the basic elements of ship design during the second half of the seventeenth century.

1706: John Hardingham, *The Accomplished Shipwright and Mariner*. Although this treatise was probably pertinent when first published, the European Magazine article (1791:26) states that "as we are at present furnished with more valuable treatises of the same kind, this work is not at all recommended for practical use." Røding was less charitable, calling it "utterly superficial" (quoted in Anderson 1921:63).

1711: William Sutherland, *The Ship-Builders Assistant*.[7] This treatise is generally considered to be the first published English work which treats the subject of naval architecture in detail. In the Preface Sutherland relates that he and "several forebears" worked in Royal Navy yards, but that his book may be "very advantageous to Merchants, Owners, and any others concerned in Shipping …." In spite of that statement, his treatise is essentially about warships. Apparently, the book was widely known, as Sutherland revised and re-issued the book several times before the final version was published in 1784. The book also includes such practical information as sparring and rigging proportions for vessels built just after the turn of the century.

1717: William Sutherland, *Britain's Glory: or, Ship-Building Unvail'd* …. This book, in two parts, contains sound practical advice for the shipbuilder, including detailed information on contracting for every facet of building a ship. Sutherland's two works provide a very detailed description of ship design technology at the beginning of the eighteenth century.

1750: Thomas Riley Blanckley, *A Naval Expositor.* The first illustrated marine dictionary in the English language. This dictionary was expensively printed with the skillfully-engraved illustrations placed next to the text entry, making it much easier to use than many other books of the day, most of which had their plates at the end or at locations convenient to the printer, rather than the reader. Had Falconer's dictionary (see below) not appeared twenty years later, this work might have enjoyed wider distribution and popularity.

1754: Mungo Murray, *Treatise on Ship-building and Navigation*, and ***Supplement to the Treatise on Ship-building*** (1765). Murray's treatise is clearly written and includes extensive information and tables of proportions on merchant shipsranging from 50 to 630 tons. The supplement, published in 1765, includes translated portions of two important French treatises: an abridged version of M. du Hamel's *Elemens de l'Architecture Navale*, 1752, which *European Magazine* termed "by far the best practical work in [the French] language" (*Eur.Mag.* 1791:), but which deals only with ships of the line, and part of M. Bouguer's *Traitè du Navire*, 1747, mentioned above.

Murray was a shipwright at Deptford, where numerous merchant ships were measured and fitted out as naval transports. His treatise begins by presenting definitions of the terms used in ship design, then clearly explains the principles of preparing plans or draughts, and, finally, demonstrates the means for projecting the draughts to the moulding loft. The principle of whole-moulding is explained, including its application to the design of large vessels. The 1765 supplement to the treatise also contains a table of masting dimensions for a variety of merchant ships.

1768: Fredrik Henrik af Chapman, *Architectura Navalis Mercatoria*, and *Tractat on Skepps-Byggeriet* (1775). Chapman's two works, probably the best-known and most-used works on eighteenth-century ship design, are also the best and most complete source of information on English and European merchant ships from that period. Chapman was the son of a British naval officer who had joined the Royal Swedish Navy and who in 1720 became captain of the Royal Dockyard at G^tteborg. Chapman's publications contain extensive information and draughts of English merchant ships, which he had studied in detail. Chapman's *Tractat on Skepps-Byggeriet* (*Treatise on Shipbuilding*) was not translated into English until 1820, and it is not known what influence the treatise had in Great Britain prior to that date. Undoubtedly, Chapman's extremely high quality draughts and illustrations which appeared in *Architectura Navalis Mercatoria* were widely known in England. The draughts, displayed on 62 engraved plates, are very detailed, represent an impressive variety of sizes and types of merchant vessels, and include scales for English, French and Swedish measurement units.

1769: William Falconer, *An Universal Dictionary of the Marine*. Falconer's dictionary provides detailed definitions of a wide variety of English and French nautical terms. In addition to definitions, the dictionary contains a 13-page summary essay under the heading "Naval ARCHITECTURE," as well as another three page essay entitled "Ship-BUILDING." For his articles on "the theory and art of ship-building" Falconer credits M. Du Hamel's *Elements of Naval Architecture*. This excellent and widely-used source was reissued several times, with a final edition in 1815 which was revised and expanded by Dr. William Burney, who listed himself as the author of the new edition.

1777: William Hutchinson, *A Treatise on Practical Seamanship*.[8] Hutchinson's treatise does not deal with naval architecture in detail; rather, its value lies in the vital information he provides on the preferred characteristics of merchant ships, especially colliers and other bulk-cargo carriers. This treatise is an essential element in the attempted analysis of late eighteenth-century merchant ships. Unlike most of the other authors, who worked in the London area, generally for the Royal Navy, Hutchinson was born in Newcastle-upon-Tyne and went to sea as a boy aboard a north-built collier. Therefore, his perspective on shipbuilding is especially important to the present study.

1781: Marmaduke Stalkartt, *Naval Architecture, or the Rudiments and Rules of Ship Building ....* The European Magazine bibliography (1791:31) credited Stalkartt's treatise with being "the amplest and most satisfactory" of those currently in print for the instructions for preparing draughts and transferring them to the moulding loft, as well as for the high quality of the large-size plates, which had "no rival among all mentioned ...." This was also the first treatise to publish plans for a wide range of vessel types, including a yacht, sloop and cutter, as well as several warships.

1788: Anonymous, *The Shipbuilder's Repository; or, a Treatise on Marine Architecture ....* The shipbuilding section of this treatise is excellent, presenting tables of proportions and scantlings for merchant ships of all sizes, in addition to those for warships. In Chapter IX the author presents ten design criteria for merchant ships, followed by proportions for four "classes" of merchant ships ranging from 100 to 800 tons.

1794: William Hutchinson, *A Treatise on Naval Architecture ... of Merchant Ships in general....* Hutchinson's treatise is important for this study because its subject is merchant ships. Hutchinson describes current merchant ship design practices and suggests improvements. He also illustrates merchant ship lines and provides proportional data and tables for design and construction.

1794: David Steel, *The Elements and Practice of Rigging and Seamanship.* Steel's rigging and seamanship book is very complete and detailed, and is certainly one of the best—and few—such works.

1797: The Third Edition of *Encyclopaedia Britannica*, published in1797, includes an extensive "Ship-Building" section that is useful because it presents design and construction information from a variety of sources.

1800-2: John Charnock, *An History of Marine Architecture*. Charnock's three-volume history begins with his speculations on the emergence of the earliest boats and progresses through a detailed history of ship development throughout the world, concentrating, in Volumes II and III, on European navies and warships. John Fincham, in his *History of Naval Architecture* (1830), below, quotes frequently from Charnock.

1805: David Steel, *The Elements and Practice of Naval Architecture*; *The Shipwright's Vade-Mecum* (1805). Steel's Naval Architecture is a detailed and superb work, a quarto book with a separate set of folio plates of excellent quality, describing a variety of warships and merchant ships. Of particular significance to the present study is Steel's description of a "collier brig" of 170 tons. In presenting nautical design information, Steel separately lists proportions for warships and merchant vessels, which is very helpful in making a comparative analysis of the two vessel types.

Since Naval Architecture was published in 1805, it seems logical to assume that the book can be viewed as a benchmark for naval architecture at the end of the eighteenth century. MacGregor (1988:16) cautions, however, that much of Steel's section on ship design, including forming midship sections with arcs of circles, seems to have been taken from earlier works, either *The Shipbuilder's Repository* or a later edition of Sutherland's *Ship-builders Assistant*. In his preface, however, Steel states that in the preparation of the treatise "actual workmen" were consulted and their methods compared by various experts "in order that the correct principles might be established, and the best practice explained (1805:iv)." Thus, one is tempted to conclude that Steel's methods resemble those presented in previous treatises because the technology of ship design had not, in fact, changed appreciably for more than a century. This possibility is discussed more fully in the next section.

1808: Darcy Lever, The Young Sea Officers Sheet Anchor .... This book provides very detailed and well illustrated information on rigging of all types.

1821: John Fincham, *An Outline of Ship Building.* This book consists of four sections: constructing the body, building, materials, and a vocabulary of terms. Fincham reviews, in Part I, several different methods used in England and France for forming the midship section, offering comments on the advantages, disadvantages and current usage of each method. Part II presents an excellent item-by-item description of every part of a ship.

1830: Peter Hedderwick, *A Treatise on Marine Architecture.* This very important publication is well illustrated with 21 separate large-size plates. The entire work concentrates on merchant ships. In Hedderwick's own words:

> The Publications on Marine Architecture, though written by the most able men in the profession, have been hitherto almost entirely adapted to Ships of War, or Merchant-Vessels of the largest dimensions; while the smaller classes, by which the commerce of the different countries of Europe is chiefly carried on, have been greatly neglected.

Although not published until 1830—after some significant changes had occurred in naval architecture—the book describes ship design in terms of both old and new methods. Because of Hedderwick's incorporation of a variety of design methods, and because of his emphasis on merchant ships, this work cannot be ignored in the present study.

Notes on Appendix B

[1] Deane's "Doctrine of Naval Architecture" of 1670, although never published, was well known, and Edward Bushnell's work, The Complete Shipwright, first published in 1664, was in its third edition by 1670.

[2] Published for the first time by The Society for Naval Research in 1958 and 1921, respectively.

[3] M. Bouguer, Traitè du navire, de sa construction et de ses mouvements, 1747, an English abridgement of which is included in Mungo Murray's Supplement to the treatise on shipbuilding, 1754, along with a summary of M. Du Hamel de Monceau's Elemens de l'architecture navale, 1752.

[4] An attempt to reconstruct these notes was made by Jon V. Pepper in Five Hundred Years of Nautical Science, published by the National Maritime Museum, Greenwich. 1981 (Lavery 1988:9).

[5] A faithful edition was publsihed in 1922 from the original manuscript by The Navy Records Society in The Life and Works of Sir Henry Mainwaring, Volume II.

[6] Deane's manuscript was not published in its entirety until 1981: Deane's Doctrine of Naval Architecture, 1670 (London, 1981: Conway Maritime Press), edited and introduced by Brian Lavery. The original manuscript has been preserved as manuscript no. 2910 in the Pepys Library, Magdalene College, Cambridge.

[7] A Facsimile was published by Jean Boudriot Publications, Rotherfield, 1989).

[8] A Facsimile was published by Scholar Maritime Press, London, 1979).

APPENDIX C

Additional Data on Eighteenth-Century British Merchant Vessels from a Variety of Sources

Contents

Data from Admiralty Records at the Public Record Office and the National Maritime Museum

Data from Public and Private Shipping Registers

Lloyd's Register of Shipping

Data from Admiralty Records at the Public Record Office and the National Maritime Museum

As discussed in Chapter 3, one of the most valuable sources of information on seventeenth- and eighteenth-century English merchant vessels is the rich and varied collection of Admiralty records relating to the procurement and operation of merchant vessels for the Royal Navy's transport and victualling services. These records hint at trends in merchant vessel size and shape during the period of interest; however, since the Navy normally specified minimum dimensions and capacity for vessels to be leased, the resulting vessel descriptions cannot be taken to represent a full cross-section of merchant vessels in commercial service. Quite the contrary, the Royal Navy generally leased only transport vessels of 200 tons or greater, with at least five feet between decks (Syrett 1970:110), above the size of the average merchant vessel of the period.

Transport records for the period of the American War for Independence are particularly extensive. During the years 1776-1783, when Britain was engaged in wars in both Europe and North America, large numbers of merchant vessels were chartered for use as victuallers and transports.

Merchant vessels chartered by the Navy Board were used as troop and horse transports, victuallers, and store ships. They carried a wide assortment of food, beverages, fuel, and military items, the latter including tents, clothing, cannon, small arms, powder and ammunition, as well as other supplies necessary for supporting a large fighting force on foreign soil.

Once a merchant vessel was offered to the Navy Board for use in the transport service it was thoroughly inspected, surveyed, measured and appraised, generally at a Royal Dockyard. If found acceptable the vessel was then chartered and fitted-out, as necessary, for its new service (Syrett 1970:100). It was the processing of leased merchant vessels which produced the most detailed records, many of which have been preserved at the Public

Record Office, Kew, London. Additional Admiralty records can be found in the research library at the National Maritime Museum, Greenwich.

Of 37 vessels inspected at Deptford Dockyard between February 1773 and February 1775 (see Table C.1), the average tonnage was 326, with a median value of 311 tons; the largest vessel measured nearly 700 tons, while the smallest was under 100 tons. All the vessels had a full body form and approximately one-half had sheathed hulls; about half had a rise forward, and two-thirds had a rise aft; all were listed as "roomly" and with good accommodations; most were slated to carry troops and horses to America; most were having lower decks laid.

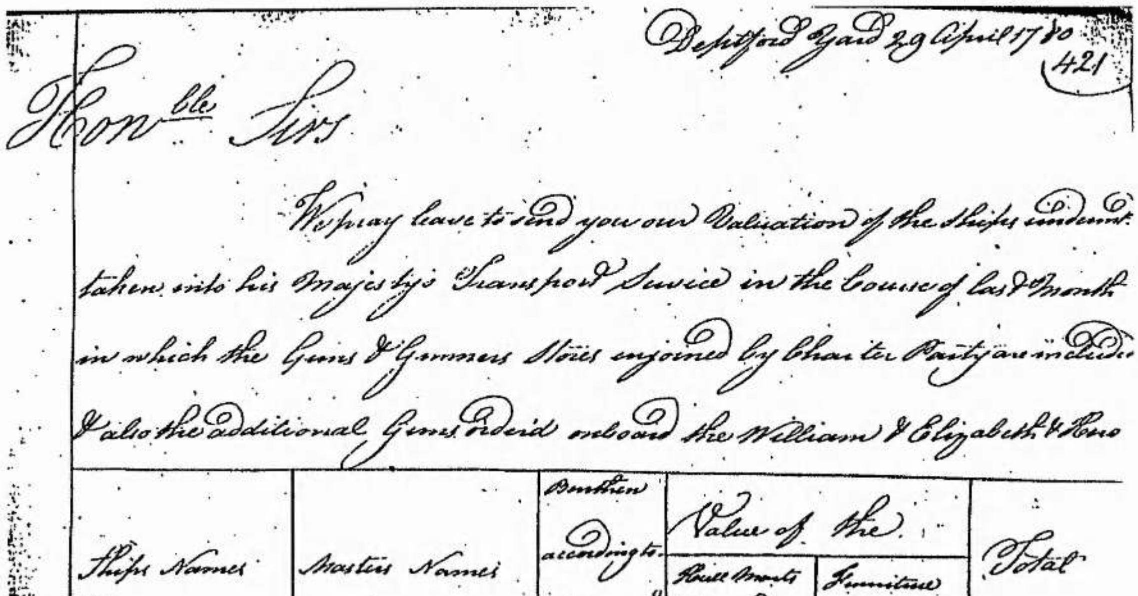
TABLE C.1
ADMIRALTY RECORD ADM 106/3402 (PUBLIC RECORD OFFICE, KEW)
Merchant Vessels Surveyed for Naval Transports, 1773 - 1775

VESSEL NAME	TONNAGE	TYPE OF VESSEL	AGE	HT.BTWN DECKS	BODY FORM	BOTTOM	RISE FORE?	RISE ABAFT?	WHERE BUILT
BRUDNELL	308	SQ-STRND	4	5.3	FULL	SINGLE	FLUSH	FLUSH	SHIELDS
ADRIATICK	206	SQ.STRND	5	4.9	FULL	SHEATHED	FLUSH	RISE TO QTRDK	AMERICA
FRIENDSHIP	291	BRIG	19	5.3	FULL	SHEATHED	FLUSH	RISE TO QTRDK	BRISTOL
ROBSON	315	BARK	1	5.8	FULL	SINGLE	Y	Y	YARMOUTH
PRINCE OF WALES	448	PINK	19	6.4	FULL	DBL.ABV.WALE ONLY		Y	WHITBY
PALLAS	345	SQ.STRND	1	6.3	FULL	SINGLE	FLUSH	FLUSH	WHITBY
HENRY	260	SQ.STRND	5	5.3	FULL	SINGLE	FLUSH	RISE	WHITBY
OTTER	83	TENDER	27			SINGLE			RIVER
PALLISSER	352	SQ.STRND	0.5	6.3	FULL	SINGLE	Y	Y	SCARBRO
RUSSIA MERCHANT	240	PINK	16	5.1	FULL	SHEATHED	Y	Y	SCARBOROUGH
EMPRESS OF RUSSIA	684	BARK	10	6.7	FULL	SHEATHED			SCARBOROUGH
THOMAS & RICHARD	387	CAT	18	6.7	FULL	SHEATHED			WHITBY
OCEAN	242	SQ.STRND	9	5.1	FULL	SHEATHED	Y	Y	WHITBY
ALICIA	320	BARK	2	5.5	FULL	SINGLE	Y	Y	WHITBY
SYMETRY	336	BARK	11	5.6	FULL	SHEATHED	Y	Y	SCARBOROUGH
HUNTER	311	BARK	13	5.9	FULL	SINGLE	YES		WHITBY
CHARMING NANCY	444	CAT	10	5.2	FULL	SINGLE		Y	SCARBOROUG
LIVELY	245	BARK	7	5.3	FULL	SINGLE	Y	Y	WHITBY
WENTWORTH	693	SQ.STRND	11	6.4	FULL	DOUBLED	FLUSH		LIMEHOUSE
SEA VENTURE	300	BARK	13	5	FULL	SHEATHED	Y	Y	SCARBOROUGH
FATHERS'GOODWILL	334	PINK	17	5.3	FULL	DOUBLED/SINGLE			WHITBY

(continued next page)

ADMIRALTY RECORD ADM 106/3402 (PUBLIC RECORD OFFICE, KEW)
Merchant Vessels Surveyed for Naval Transports, 1773 - 1775 (continued)

VESSEL NAME	TONNAGE	TYPE OF VESSEL	AGE	HT.BTWN DECKS	BODY FORM	BOTTOM	RISE FORE?	RISE ABAFT?	WHERE BUILT
COUNTESS OF DARLINGTON	265	BRIG	4	5.3	FULL	SHEATHED	FLUSH	Y	WHITBY
CODRINGTON	177		0.8						
NONPAREIL	181								
GRAND DUTCHESS OF RUSSIA	308	BARK	1	5.4	FULL	SINGLE	Y	Y	WHITBY
ISABELLA	362	BARK	11	5.4	FULL	SHEATHED	Y	Y	SCARBOROUGH
BETSEY	252	BARK	2	4.7	FULL	SINGLE	Y	Y	HULL
EAGLE	344	CATT	25	5.8	FULL	SHEATHED			WHITBY
PROSPEROUS ARMELLA	382	CATT	27	5.5	FULL	SHEATHED			HULL
GLENN	305	SHIP	13	5.6	FULL	SHEATHED	Y		BRISTOW
JAMES & WILLIAM	394	BARK	1	6.9	FULL	SINGLE	Y	Y	WHITBY
UNION	238	SQ.STRND	11	5.7	FULL	SHEATHED	FLUSH	Y	AMERICA
DOROTHY & CATHERINE	372	BARK			FULL	SINGLE	Y	Y	WHITBY
BRITANNIA	372	CAT	25	5.1	FULL	SHEATHED			WHITBY
JOHN & REBECCA	276	BARK	2.5	5.6	FULL	SHEATHED	Y	Y	AMERICA
LOVE & UNITY	413	CAT	13	6.5	FULL	SINGLE	Y	Y	WHITBY
FRANCIS	262	SHIP	0.5	4.9	FULL	SINGLE	FLUSH	Y	AMERICAN
AVERAGE =	326		10.1	5.6					
MEDIAN =	311		10.0	5.5					
GREATEST =	693		27.0	6.9					
LEAST =	83		0.5	4.7					



Deptford Yard 29 April 1780

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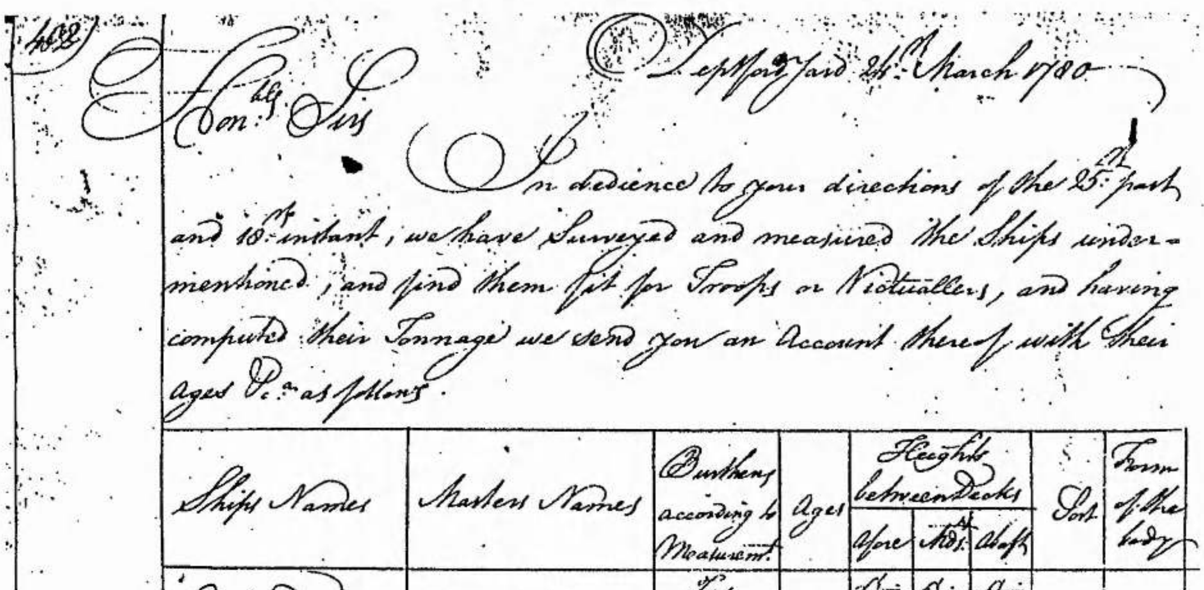
Hon.ble Sirs

We pray leave to send you our Valuation of the Ships undermentioned taken into his Majesty's Transport Service in the Course of last Month in which the Guns & Gunners Stores enjoined by Charter Party are included & also the additional Guns ordered onboard the William & Elizabeth & Hero

Ships Names	Masters Names	Burthen according to Measurement	Value of the Hull Masts & Yards	Value of the Furniture & Stores	Total
		Tons	£ . s . d	£ . s . d	£ . s . d
Duke William	John Stevenson	423 85/94	2119. 0. 0	1433. 0. 0	3552. 0. 0
Holmpton	Thos. Davidson	676 71/94	4399. 0. 0	1828. 0. 0	6227. 0. 0
Success	Wm. Thompson	234 28/94	1054. 5. 0	914. 15. 0	1969. 0. 0
William & Elizabeth	Thos. Eggar	469 57/94	2289. 5. 0	1728. 15. 0	4018. 0. 0
Dize	John Schofield	369 41/94	2771. 5. 0	1368. 15. 0	4140. 0. 0
Enterprize	Joseph Hutchinson	266 82/94	1401. 5. 0	1034. 15. 0	2436. 0. 0
Brothers	John Moore	204 24/94	1532. 0. 0	944. 0. 0	2476. 0. 0
Hercules	Thos. Wright	705 35/94	4588. 5. 0	2116. 15. 0	6705. 0. 0
Prince of Wales	George Gibbs	332 48/94	2327. 10. 0	1133. 10. 0	3461. 0. 0
Emerald	Willm. Tindall	215 60/94	1614. 5. 0	914. 15. 0	2529. 0. 0
Ranger	John Wood	245 80/94	1845. 0. 0	976. 0. 0	2821. 0. 0
Hero	John Sanderson	275 36/94	1342. 10. 0	1137. 10. 0	2480. 0. 0

Hon.ble Navy Board

Typical entry in the Deptford Dockyard books for the valuation of merchant vessels being surveyed for possible acquisition as transports or victuallers.



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Deptford Yard 24th March 1780

Hon.ble Sirs

In obedience to your directions of the 25th past and 18th instant, we have Surveyed and measured the Ships undermentioned, and find them fit for Troops or Victuallers, and having computed their Tonnage we send you an Account thereof with their Ages &c.a as follows.

Ships Names	Masters Names	Burthens according to Measurem.t	Ages	Heights between Decks Afore	Midsh.	Abaft	Sort	Form of the body
		Tons		Ft In	Ft In	Ft In		
Emerald	Will.m Tindall	215 19/94	New	5.8	5.5	6.0	Brig	full
Hero	John Sanderson	275 36/94	Yrs 8	5.3	5.3	5.8	Ship	full

Emerald — built at Scarbro', bottom Sheathed, a proper lower Deck and now at Deptford reported ready in all respects.

Hero — French built, bottom Sheathed, a proper lower Deck and getting ready to come down as soon as possible.

Hon.ble Navy Board — A.G. C.B. J.P.

Entry in the Deptford Dockyard books for the valuation of the merchant vessels Emerald *and* Hero, *both being surveyed for possible acquisition as transports.*

Data from Public and Private Shipping Registers

Customs House Port Registers

Port records and vessel information dating to before the late eighteenth century are scarce. Although scattered fragments of earlier information can be found, they are not sufficient to permit a detailed comparative study. An act of 1696 called for the registration of English vessels engaged in trade with the colonies, but few such records survive (7 & 8 William III cap.18; Jarvis 1972:42-3). The Registry Act of 1786 was of great benefit to researchers since it specified the compulsory registration of all British vessels of 15 tons or more, to provide for "the further increase and encouragement of shipping and navigation" (26 George III cap.60). In 1786, in response to the Registry Act, all British customs houses began maintaining registers describing British-owned vessels belonging to their port. All information was recorded in register-books, as summarized in the following tables.

KEY TO VESSEL TYPES

s	stern	qb	quarter badges
st or ss	square tuck stern	ql	quarter lights
s and st	square and square tucked stern	g	gallery
		rh	roundhouse
r or rs	round stern		
p or ps	pink stern	bg	brig
h	hagboat stern	bt	brigan-
b	break in deck		
qd	quarter deck		
hqd	high quarter deck		
qg	quarter galleries		

TABLE C.2
SAMPLING OF ENTRIES FROM THE LONDON PORT REGISTRY, 1786-87

Where Built	Age	No. Dks	No. Msts	Length	Beam	Ht.Btw Decks	Dpth Hold	Ton-nage	Type
YORKSHIRE	15	2	2	77.0	23.7	3.9		175	SSBG
KENT	16	1	1	40.0	15.8		6.3	36	SSSP
RIVER THAMES	39	1	1	52.0	16.5		9.2	54	PSSM
ESSEX	23	1	1	50.0	16.3		8.8	50	RSSM
KENT	14	1	1	31.0	11.8		7.9	16	SSY
KENT	17	1	1	34.0	13.5		7.0	53	PSSM
ESSEX	24	1	1	51.0	16.3		9.4	53	PSSM
SURREY	9	1	1	59.8	18.3		9.3	79	SSSM
KENT	4	1	1	59.8	18.3		9.3	79	SSSM
KENT	36	1	1	37.7	14.2		7.0	28	SSSM
SUFFOLK	33	1	1	37.7	14.2		7.0	28	SSSM
RIVER THAMES	17	1	1	36.0	14.0		7.0	26	SSY
RIVER THAMES	1	1	1	43.7	14.7		8.5	36	SSSM
SUFFOLK	14	1	1	43.0	14.3		6.3	17	SSY
SUFFOLK	3	1	1	32.0	12.0		6.3	17	SSY
R.THAMES	21	1	1	43.8	16.3		6.2	44	RSH
R.THAMES	26	1	1	45.5	13.5		6.0	33	SSH
KENT	11	1	1	39.0	14.5		8.0	30	SSY
SURREY	26	1	1	53.0	16.5		7.5	55	RSH
YORKSHIRE	5	1	1	64.5	20.3		10.3	110	SSSP
KENT	22	1	1	52.0	17.5		10.5	61	SSSM
KENT	3	1	1	33.0	12.4		4.2	18	SSY
ESSEX	3	1	1	34.5	13.6		7.0	23	SSY
R.THAMES	19	1	1	37.0	13.0		7.0	24	SSSM
DURHAM	25	2	2	98.0	26.6	5.2		281	SSSN
SUFFOLK	24	1	1	54.0	17.7		4.5	56	BARGE
R.THAMES	12	1	1	54.0	17.7		4.5	56	BARGE
R.THAMES	3	1	1	57.3	16.5		5.4	55	BARGE
R.THAMES	22	1	1	53.5	15.0		4.2	42	BARGE
KENT	6	1	1	36.0	13.0		4.5	23	SSY
R.THAMES	44	1	1	43.0	14.7		8.8	41	SSSM
YORKSHIRE	2	1.5	2	69.0	22.1			129	SSBG
YORKSHIRE	4	2	3	87.5	24.5			210	SSS
KENT	23	1	1	37.0	14.3		5.0	28	SSY
LINCOLN	19	1.5	2	62.6	19.8	3.3		96	SSBG
KENT	13	1	1	41.5	17.2		6.6	43	SSLR
YORKSHIRE	1	1	2	70.1	20.4		10.8	119	SSBG
R.THAMES	5	1	1	32.0	12.5		6.0	18	SSY
R.THAMES	14	1	1	54.5	17.5		4.5	53	BARGE
R.THAMES	34	1	1	55.6	16.1		4.7	50	BARGE
R.THAMES	17	1	1	49.0	17.3		8.3	54	RSH

(continued)

London Registry (cont.)

Where Built	Age	No. Dks	No. Msts	Length	Beam	Ht.Btw Decks	Dpth Hold	Ton-nage	Type
R.THAMES	21	1	1	53.8	15.5		3.8	45	BARGE
DURHAM	10	2	2	71.0	21.5	4.1		129	SSBG
KENT	7	1	1	36.7	14.0		5.0	26	SS
LIVERPOOL	17	1	2	70.5	21.8		10.3	133	PS bg
CUMBERLAND	12	1.5	3	89.3	25.9		6.5	242	SSS
R.THAMES	21	1	1	57.3	16.3		4.7	54	barge
R.THAMES	19	1	1	44.0	18.5		7.0	52	RS
HANTS	26	2	2	63.5	18.3	3.9		83	ss bg
NEWCASTLE	5	1	1	48.3	16.1		8.0	48	hagboat
KENT	2	1	1	52.6	16.3		8.8	55	SS sm
YORK	12	1	2	58.5	19.0		9.3	82	SS bg
KENT	5	1	1	33.5	12.2			18	SS Y
KENT	12	1	1	38.0	14.9		4.7	31	SS Y
R.THAMES	0	1	1	60.0	18.1		4.8	64	barge
KENT	16	1	1	37.8	14.8		4.6	30	SS Y
R.THAMES	9	1	1	65.0	15.8		4.8	63	barge
LIVERPOOL	11	2	3	77.0	23.8	5.0		176	SSS
YORKSHIRE	0	1	2	73.0	22.8		3.3	151	SS bg
R.THAMES	5	1	1	28.0	10.8		4.8	12	SS Y
KENT	3	1	1	40.3	14.3		6.0	31	SS Y
KENT	16	1	1	39.0	16.5		6.5	35	r SS
ISL. OF WIGHT	2	1	1	41.0	14.8		7.3	33	SSSP
KENT	5	1	1	33.5	13.0		4.4	21	SS Y
KENT	0	1	1	31.5	11.5		3.9	15	SS Y
MERIDNETH	1	1	1	59.0	19.7		10.0	88	SSSP
R.THAMES	2	1	1	24.5	9.3		3.0	7	SS Y
R.MEDWAY	4	1	1	46.0	16.5		7.0	47	rs hoy
CHESTER	14	2	3	75.3	22.9	4.6		163	SSS
R.THAMES	7	1	1	53.5	15.3		3.5	45	barge
R.THAMES	0	1	1	57.3	17.6		5.0	62	barge
KENT	0	1	1	44.3	17.5		8.8	53	rs s
ESSEX	2	1	1	43.5	15.6		9.0	41	SS SM
ESSEX	1	1	1	31.5	12.0		6.0	17	SS Y
R.THAMES	18	1	1	40.0	17.5		7.0	42	rs l
KENT	17	1	1	35.0	14.0		4.7	25	SS Y
R.THAMES	13	1	1	42.3	14.0		8.0	32	PSSM
R.THAMES	0	1	1	64.5	19.6		5.5	86	SS S
AVERAGES	12.6			50.0	16.6	4.3	6.6	62.0	L/B = 3.01
MEANS	12.0			47.2	16.3	4.1	6.5	47.5	= 2.90
GREATEST	44.0			98.0	26.6	5.2	10.8	281.0	= 3.68
LEAST	0.0			24.5	9.3	3.3	3.0	7.0	= 2.63

TABLE C.3
SAMPLING OF ENTRIES FROM THE NEWCASTLE PORT REGISTRY, 1786-87

Where Built	Age	No. Dks	No. Msts	Length	Beam	Ht.Btw Decks	Dpth Hold	Ton-nage	Type
S.SHIELDS	2	2	2	100.5	26.7	5.5		280	SSSN
S.SHIELDS	3	2	3	105.0	27.8	5.3		313	SSBK
N'CASTLE	13	2	2	93.5	26.7	4.6		255	SSSN
NEWCASTLE	2	2	2	80.6	23.5	3.9		163	SSBT
NEWCASTLE	3	2	2	77.7	24.4	4.0		163	SSBT
GATESHEAD	7	2	3	104.8	26.8	5.0		288	SSBK
S.SHIELDS	3	2	2	90.3	25.7	4.8		217	SSBT
NEWCASTLE	5	2	2	99.5	27.3	5.0		285	SSSN
NEWCASTLE	5	2	2	92.0	25.3	5.1		225	SSBT
KNGSTN ON HULL	29	1	1	52.9	16.8		8.0	54	SSSP
S.SHIELDS	11	2	2	90.2	22.7	4.3		187	SSBT
NEWCASTLE	7	2	3	111.7	28.5	5.0		353	SSBK
NEWCASTLE	16	2	2	89.0	23.7	4.3		187	SSBT
S.SHIELDS	0	2	3	104.3	27.5	5.6		297	SSBK
N.SHIELDS	25	2	3	105.1	27.8	5.1		326	SSBK
NEWCASTLE	14	1	2	82.6	23.7		13.7	182	SSSN
HULL	14	2	2	69.0	20.2	3.3		111	SSBT
NEWCASTLE	2	1	2	82.0	24.8		14.4	198	SSBT
NEWCASTLE	25	2	2	88.2	26.2	5.1		230	PSBT
STOCKTON	36	2	2	93.9	26.3	5.5		248	SSBT
W.STOCKWITH	25	2	3	93.3	23.3	5.3		200	SSBK
NEWCASTLE	0	2	2	96.7	26.2	4.8		251	SSBT
S.SHIELDS	1	2	2	93.5	25.3	4.8		224	SSBT
SHOREHAM	33	2	2	93.6	22.2	4.1		183	PSBT
BLYTHNOOK	0	1	2	80.8	24.9		15.2	212	SSSN
SCARBORO	32	2	2	85.4	23.7	4.3		181	SSBT
HOWDON PANS	2	2	3	98.1	28.5	5.3		303	SSBK
N.SHIELDS	22	2	2	95.5	26.6	3.9		267	SSBT
HOWDONPANS	12	1	2	75.8	24.4		13.5	140	PSBT
WHITBY	30	2	3	105.0	27.7	4.6		307	PSV
BLYTH	1	1	2	76.4	24.3		13.9	175	SSBT
HOWDONPANS	13	1	2	69.9	21.4		8.5	124	SSBT
NEWCASTLE	19	1	2	65.8	24.8		11.1	117	PSBT
WHITBY	1	2	2	96.3	26.5	4.8		253	SSBT
WHITBY	21	2	3	102.0	28.4	5.0		316	SSBK
N.SHIELDS	1	2	2	92.3	26.5	4.9		241	SSBT
LONDON*	20	2	2	88.2	23.1	5.3		196	SSBT
GATESHEAD	27	2	3	110.6	27.6	5.1		333	SSBK
N.SHIELDS	7	2	3	109.7	28.2	4.4		339	SSBK
NEWCASTLE	10	1	2	72.4	20.5		10.2	125	SSBT
N.SHIELDS	9	2	2	89.8	24.9	4.9		218	SSBT

(continued)

Newcastle Registry (cont.)

Where Built	Age	No. Dks	No. Msts	Length	Beam	Ht.Btw Decks	Dpth Hold	Ton-nage	Type
N.SHIELDS	2	2	2	98.2	26.1	4.9		266	PSSN
N.SHIELDS	2	2	2	93.1	26.0	5.3		251	SSBT
LOW LIGHTS	5	2	3	103.6	26.1	5.5		282	SSBK
N.SHIELDS	3	2	3	113.6	28.5	6.0		356	SSBK
S.SHIELDS	2	1	1	53.5	17.8		6.9	66	SSSL
S.SHIELDS	6	2	2	96.2	26.5	5.3		260	SSBT
S.SHIELDS	5	2	2	98.1	25.1	4.8		255	SSBT
N.SHIELDS	6	2	3	105.1	27.5	5.5		310	SSS
S.SHIELDS	4	2	2	102.0	27.3	5.5		291	SSBT
BLYTH	3	1	2	85.6	24.9		16.4	216	SSBT
BLYTH	1	1	1	44.8	15.4		6.3	43	SSSL
N.SHIELDS	24	2	3	97.2	26.8	5.8		260	PSS
S.SHIELDS	0	2	2	90.3	28.2	5.4		309	SSBT
S.SHIELDS	1	2	3	89.3	25.1	4.8		222	SSBK
S.SHIELDS	5	2	3	100.2	24.5	6.3		247	SSBK
NEWCASTLE	28	3	3	108.8	28.2	4.3		335	PSC
NEWPORT	0	1	2	85.6	25.2		16.2	213	SSBT
N.SHIELDS	0	2	2	80.6	26.3	4.7		238	SSBT
S.SHIELDS	2	2	2	74.1	20.5	3.9		116	SSBT
STOCKWITH	36	2	2	80.8	20.0	3.6		130	PSSN
SCARBOROUGH	30	2	2	92.3	25.6	5.9		230	PSBT
WHITBY	28	2	3	93.1	24.9	5.3		224	PSS
YARMOUTH	8	1	2	76.1	22.3		10.1	154	SSBT
S.SHIELDS	0	2	2	82.1	23.2	3.7		167	SSSN
S.SHIELDS	1	2	2	87.3	26.1	4.9		232	SSBT
NEWCASTLE	1	1	2	73.3	21.7			136	SSBT
HOWDONPANS	2	1	1	54.0	18.4		8.6	77	PSSL
W.STOCKWITH	22	2	2	95.0	24.5	4.1		227	SSBT
SUNDERLAND	8	2	2	88.3	26.8	4.4		226	SSBT
AMERICA*	30	2	2	86.9	24.3	4.5		228	SSBT
SCARBOROUGH	36	2	2	72.2	21.7		4.3	128	PSBT
CHESTER	36	2	3	104.7	26.1	5.2		291	SSBK
S.SHIELDS	6	2	3	106.1	26.2	5.1		290	SSBK
SCARBOROUGH	9	1	3	89.8	24.4		15.6	216	SSBK
BLYTH	3	1	1	48.0	16.3		8.2	53	SSSL
S.SHIELDS	3	2	3	98.5	26.1	4.5		255	SSBK
SCARBOROUGH	21	1	2	81.4	23.6		15.4	186	SSBT
BLYTH	0	1	1	43.2	15.8		6.4	41	SSSL
BURROWBRIDGE	0	1	1	46.9	15.6		6.2	45	SSSL
N.SHIELDS	8	2	2	97.5	27.2	5.3		278	SSBT

(continued)

Newcastle Registry (cont.)

Where Built	Age	No. Dks	No. Msts	Length	Beam	Ht.Btw Decks	Dpth Hold	Ton-nage	Type
SCARBOROUGH	46	1	2	79.8	22.6		15.9	167	PSBT
BLYTH	3	2	3	91.9	23.9	4.3		201	SSBK
SUNDERLAND	3	2	3	94.3	27.7	4.4		264	SSBK
SCARBOROUGH	20	2	2	72.6	20.3	3.7		111	SSBT
NEWCASTLE	21	2	2	87.9	24.1	4.7		207	SSBT
NEWCASTLE	21	2	3	88.8	23.1	5.0		198	SSBK
NEWCASTLE	20	2	2	75.7	26.3	3.9		189	SSBT
NEWCASTLE	24	2	2	89.1	24.0	4.0		199	PSBT
GLASGOW	9	2	3	95.0	26.0	4.7		244	SSBK
WHITBY	35	1	2	82.1	23.4		15.2	180	PSBT
NEWCASTLE	20	1	2	70.5	22.3		12.1	137	SSBT
S.SHIELDS	4	2	3	104.8	27.6	5.3		306	SSBK
NEWCASTLE	17	2	2	72.1	20.2	3.3		114	SSBT
BLYTH	1	1	1	49.3	14.8		7.0	41	SSSL
HULL	50	2	2	82.6	23.7	4.5		179	PSBT
NEWCASTLE	6	2	3	100.8	27.3	5.3		284	SSBK
SUNDERLAND	23	2	3	90.9	24.1	4.5		206	SSBK
HARTLEYPANS	5	2	2	95.5	25.3	4.3		222	SSSN
NEWCASTLE	5	2	2	103.3	28.0	4.9		304	SSSN
SCARBOROUGH	36	2	3	93.6	25.8	4.4		244	RSC
SUNDERLAND	33	1	2	55.5	16.3		8.7	59	PSBT
HOWDONPANS	3	1	2	66.1	19.0		9.7	106	SSBT
WHITBY	21	2	3	97.2	25.0	5.0		210	SSBK
S.SHIELDS	10	2	2	93.9	26.1	4.3		252	SSBT
S.SHIELDS	4	2	3	94.7	26.3	4.4		246	SSBK
NEWCASTLE	30	2	3	96.7	24.1	5.3		240	PSS
S.SHIELDS	3	2	3	110.0	29.1	5.3		366	SSBK
SCARBOROUGH	69	2	3	88.9	24.4	4.0		218	PSS
S.SHIELDS	1	2	2	85.2	24.3	4.2		209	SSSN
NEWCASTLE	0	2	2	94.0	27.0	4.6		257	SSSN
WHITBY	23	2	2	92.7	22.2	4.1		193	SSBT
NEWCASTLE	9	1	2	69.2	20.7		12.6	118	SSBT
SCARBOROUGH	15	2	2	86.2	24.0	3.1		198	SSBT
N.SHIELDS	23	2	3	90.0	27.2	5.3		259	SSBK
WHITBY	34	2	3	101.6	28.1	5.1		323	PSS
SCARBOROUGH	11	1.5	2	72.6	21.0	4.3		128	SSBT
S.SHIELDS	8	2	3	100.7	28.6	5.0		338	SSBK
SUNDERLAND	3	2	3	92.1	26.7	4.1		265	SSBK
NEWCASTLE	3	2	2	96.4	27.3	4.9		284	SSSN
WHITBY	0	2	2	91.1	27.0	4.1		267	SSBT

(continued)

Newcastle Registry (cont.)

Where Built	Age	No. Dks	No. Msts	Length	Beam	Ht.Btw Decks	Dpth Hold	Ton-nage	Type
STOCKTON	21	2	3	89.1	25.0	4.8		226	SSBK
NEWCASTLE	2	1.5	2	82.2	24.8	4.9		203	SSBT
NEWCASTLE	3	2	2	92.4	26.1	4.6		253	SSBT
SCARBOROUGH	2	1	2	58.0	18.5		9.3	77	SSBT
WHITBY	7	2	3	114.0	30.3	5.3		423	BK
WHITBY	8	2	2	84.5	26.0	4.8		230	SSSN
S.SHIELDS	0	2	2	88.2	25.1	4.8		230	SSBT
S.SHIELDS	0	1.5	2	71.3	23.2	4.0		151	SSBT
NEWCASTLE	0	1.5	2	91.9	27.9	5.1		291	SSBT
SCARBOROUGH	21	1.5	2	93.2	25.4	5.4		246	SSSN
S.SHIELDS	0	2	3	90.3	26.1	4.3		256	SSBK
SCARBOROUGH	6	2	3	86.0	25.0	4.0		207	SSS
									L/B Ratio
AVERAGES	12.3	1.8	2.3	87.7	24.6	4.7	11.0	217.6	3.57
MEANS	7.0	2.0	2.0	90.3	25.1	4.8	10.2	225.0	3.60
GREATEST	69	3	3	114	30.3	6.3	16.4	423	3.76
LEAST	0	1	1	43.2	14.8	3.1	4.3	41	2.92

TABLE C.4
SAMPLING OF ENTRIES FROM THE WHITBY PORT REGISTRY, 1786-87

Where Built	Age	No. Dks	No. Msts	Length	Beam	Ht.Btw Decks	Dpth Hold	Ton-nage	Type
S.SHIELDS	11	2	1	51.0	17.3	4.0		52	SLP
WHITBY	13	2	2	63.6	18.8	4.9		85	SSBT
SCARBRO	32	2	1	53.5	15.6	3.9		50	SSSLP
S.SHIELDS	18	2	2	57.3	18.0	2.1		59	SSBT
WHITBY	33	2	3	110.3	29.8	4.2		377	SSBQ
WHITBY	71	2	3	94.0	25.8	4.9		245	PSCAT
SCARBRO	12	2	2	92.8	25.4	4.8		231	SSBT
S.SHIELDS	17	1	1	50.8	16.1		8.0	49	SSSLP
WHITBY	9	2	3	97.8	27.4			271	SSBK
STAITHES	17	1	1	50.4	16.4		5.1	53	SSSLP
WHITBY	11	2	3	90.0	26.0	4.7		201	BK
WHITBY	46	2	3	101.2	28.5	6.1		334	SSBG
WHITBY	21	2	3	100.2	29.9	4.8		327	SSBK
WHITBY	8	1	2	67.8	20.5		11.8	116	SSBT
WHITBY	9	2	3	97.4	27.6	6.4		303	RSVES
WHITBY	10	2	3	94.0	27.0	4.8		270	BK
WHITBY	30	2	3	100.7	28.5	6.5		332	SSSHIP
WHITBY	16	2	3	103.5	28.2	4.9		332	BK
WHITBY	33	2	3	95.5	27.0	3.9		282	BK
SCARBRO	27	2	3	92.4	25.6	4.8		253	SSS
SCARBRO	26	1	3	50.9	14.4		5.3	42	SSBG
WHITBY	21	2	3	99.2	28.0	5.8		316	SSBK
WHITBY	34	2	3	100.0	20.9	6.8		340	RSS
WHITBY	8	1	2	71.0	20.8		11.4	122	SSBT
WHITBY	8	1	2	60.9	19.0		11.3	93	SSBT
STAITHES	22	1	3	47.3	15.3		4.4	48	SSLUG
STAITHES	18	1	3	52.7	15.0		5.3	46	SSLUB
WHITBY	7	2	3	91.7	25.8	5.8		247	SSS
WHITBY	7	2	3	102.3	27.2	5.5		311	SSS
WHITBY	8	2	3	93.3	25.8	5.8		260	SSS
WHITBY	7	2	2	93.3	26.3	5.5		267	SSSN
WHITBY	6	2	2	76.8	22.6	4.4		159	SSSN
WHITBY	6	2	3	86.6	24.7	4.1		205	SSS
WHITBY	5	1	1	59.0	17.9		9.3	79	SSSLP
WHITBY	5	2	2	79.5	22.6	4.4		165	SSBT
WHITBY	0	2	3	88.8	24.4	2.9		219	SSSLP
WHITBY	0	2	3	99.0	28.2	6.3		332	SSS
WHITBY	0	2	3	100.0	28.3	6.5		330	SSS
WHITBY	16	2	3	99.6	27.1	5.8		281	SSS

(continued)

Whitby Registry (cont.)

Where Built	Age	No. Dks	No. Msts	Length	Beam	Ht.Btw Decks	Dpth Hold	Ton-nage	Type
WHITBY	23	1	2	50.0	15.4		8.2	51	SSBT
SCARBRO	26	1	1	53.3	15.9		7.3	53	SSSLP
WHITBY	2	2	3	107.8	30.9	6.7		409	SSS
WHITBY	2	2	3	108.7	29.1	5.8		397	SSS
WHITBY	2	2	3	98.9	28.1	5.7		313	SSS
WHITBY	49	1	1	43.5	15.4		6.5	43	SSSLP
WHITBY	3	2	3	99.5	26.8	5.7		316	SSS
WHITBY	3	2	3	92.8	27.3	4.7		286	SSS
WHITBY	3	2	3	90.1	25.8	4.7		251	SSS
WHITBY	4	2	3	90.8	25.0	4.7		233	SSS
WHITBY	4	2	3	106.0	29.2	5.5		380	SSS
WHITBY	16	1	1	48.2	16.3		7.9	55	SSSLP
WHITBY	5	2	2	81.8	23.8	4.9		193	SSBT
WHITBY	11	2	3	54.3	17.7	3.6		61	SSSLP

									L/B Ratio
AVERAGES	15.1			81.9	23.4	5.1	7.8	210	3.50
MEANS	10.5			92.1	25.7	4.9	7.9	246	3.58
GREATEST	71.0			110.3	30.9	6.8	11.8	409	3.57
LEAST	< 1			43.5	14.4	2.1	4.4	42	3.02

TABLE C.5
SAMPLING OF ENTRIES FROM THE WHITEHAVEN PORT REGISTRY, 1786-87

Where Built	Age	No. Dks	No. Msts	Length	Beam	Ht.Btw Decks	Dpth Hold	Ton-nage	Type
WHITEHAVEN	16	1	2	68.6	20.9		12.0	119	HS
LANCASTER	9	1	1	47.0	16.8		8.0	54	SS
WHITEHAVEN	4	1	3	85.2	25.8		16.4	229	HS
CHEAPSTON	26	1	3	77.8	23.4		13.5	174	HS
MARYPORT	2	1	2	62.0	20.6		11.3	106	SS
WHITEHAVEN	1	1	2	79.9	24.2		15.5	192	SS
WHITEHAVEN	12	1	2	66.8	21.5		12.5	129	HS
LANCASTER	6	1	1	51.5	17.0		9.7	52	SS
MARYPORT	3	1	2	71.8	22.8		13.5	148	SS
WHITEHAVEN	2	1	3	81.5	23.8		15.4	185	SS
WHITEHAVEN	23	1	2	61.0	18.2		11.0	87	HS
WORKINGTON	3	1	2	67.6	21.7		13.0	122	SS
WHITEHAVEN	2	1	2	70.6	22.9		13.8	149	SS
WORKINGTON	13	1	2	70.6	22.6		13.6	147	HS
WORKINGTON	2	1	2	77.0	23.3		14.3	164	HS
WHITEHAVEN	8	1	2	71.4	22.6		14.0	152	HS
WHITEHAVEN	23	1	2	55.8	19.1		10.5	85	HS
MARYPORT	1	1	2	64.0	21.0		12.0	110	SS
S.SHIELDS	20	1	3	71.1	22.6		12.9	143	HS
WORKINGTON	40	1	2	63.8	22.2		12.2	122	SS
MARYPORT	2	1	2	70.8	22.5		13.6	140	SSBT
WORKINGTON	8	1	2	67.3	21.9		13.3	130	HS
WORKINGTON	2	1	2	72.7	22.5		13.3	142	HS
SUNDERLAND	2	1	2	64.2	21.3		11.4	111	SS
TOPSHAM	36	1	2	62.0	16.6		9.8	72	SS
MARYPORT	5	1	2	71.2	22.8		13.9	149	SS
WORKINGTON	12	1	2	77.3	24.1		15.0	180	HS
WHITEHAVEN	9	1	2	82.2	24.1		14.7	185	SS
WHITEHAVEN	21	1	2	71.4	20.0		11.0	100	HS
WHITEHAVEN	17	1	2	57.0	18.3		9.3	78	HS
WORKINGTON	17	1	2	53.8	18.0		9.3	69	HS
CHESTER	22	1	2	75.0	22.8		12.8	156	HS
CHESTER	36	1	2	68.8	21.5		12.3	124	HS
WHITEHAVEN	22	1	2	75.0	21.6		13.0	137	HS
SALT COATS,ULVM	18	1	2	66.0	20.4		10.7	107	SS
LANCASTER	11	1	2	57.2	16.9		8.7	66	HS
WHITEHAVEN	1	1	2	73.0	23.3		13.8	155	SSBT
DUMBARTON,N.BR.	20	1	2	55.0	19.2		10.7	77	SS
BLYTH	10	1	2	74.2	22.0		13.1	145	SS

(continued)

Whitehaven Registry (cont.)

Where Built	Age	No. Dks	No. Msts	Length	Beam	Ht.Btw Decks	Dpth Hold	Ton-nage	Type
WHITEHAVEN	37	1	2	69.8	20.8		12.4	122	HS
LANCASTER	16	1	1	44.0	15.0		6.3	38	HS
WORKINGTON	25	1	2	61.7	20.0		10.8	100	HS
LANCASTER	30	1	2	58.3	17.7		9.7	74	HS
WORKINGTON	18	1	2	70.0	22.2		13.3	145	HS
WHITEHAVEN	39	1	2	72.3	22.8		12.3	151	SS
WHITEHAVEN	14	1	2	66.4	19.9		10.7	99	HS
DOUGLASS,I.O MAN	17	1	2	47.6	16.2		9.1	52	SS
MARYPORT	3	1	2	77.2	24.2		14.3	176	SS
WHITEHAVEN	30	1	2	57.2	18.1		9.9	77	HS
MARYPORT	1	1	2	61.5	20.6		11.8	102	SS
MARYPORT	20	1	2	54.6	17.8		10.3	69	HS
CHEAPSTOW	23	1	2	56.0	19.6		10.4	83	HS
WHITEHAVEN	23	1	2	67.0	19.0		11.5	104	HS
CHESTER	32	1	2	64.4	21.1		11.2	112	HS
MARYPORT	22	1	2	58.0	18.8		10.2	83	HS
WORKINGTON	34	1	2	62.0	20.5		10.0	102	HS
CHESTER	22	1	2	62.0	19.9		11.2	98	HS
WORKINGTON	3	1	2	69.8	22.3		13.5	135	SS
WHITEHAVEN	14	1	2	66.7	20.6		12.8	112	HS
CHESTER	27	1	2	70.0	21.4		13.5	135	HS
CHEAPSTOW	18	1	2	51.0	16.7		9.2	54	SS
ULVERSTONE	32	1	2	47.9	16.7		8.8	52	SS
WHITEHAVEN	2	1	2	64.4	20.6		11.7	111	SS
WORKINGTON	1	1	2	77.1	23.0		14.0	158	HS
NEWCASTLE	1	1	2	81.3	24.1		14.7	190	SS
MARYPORT	20	1	2	71.0	22.6		12.1	146	HS
WHITEHAVEN	13	1	2	72.0	22.6		13.2	150	HS
WORKINGTON	19	1	2	68.3	20.3		11.8	128	HS
MARYPORT	22	1	2	62.8	20.4		10.6	106	HS
WHITEHAVEN	1	1	2	73.5	23.6		14.0	166	SS
WHITEHAVEN	19	1	2	73.0	22.7		12.8	156	HS
WHITEHAVEN	2	1	2	80.0	24.0		15.3	188	SS
WORKINGTON	21	1	2	72.8	23.0		14.7	158	HS
NEWCASTLE	2	1	2	80.0	24.4		14.3	188	SS
CHESTER	23	1	3	77.7	23.3		14.7	172	SS
WHITEHAVEN	13	1	3	85.0	24.2		15.3	210	HS
WORKINGTON	4	1	2	70.5	22.7		13.5	144	SS
WHITEHAVEN	2	1	3	80.8	25.5		16.8	223	SS

(continued)

Whitehaven Registry (cont.)

Where Built	Age	No. Dks	No. Msts	Length	Beam	Ht.Btw Decks	Dpth Hold	Ton-nage	Type
WHITEHAVEN	36	1	2	70.0	22.4		13.8	142	HS
WHITEHAVEN	4	1	2	98.4	27.6		18.8	300	SS
WHITEHAVEN	12	1	3	79.4	23.8		14.8	183	HSS
WORKINGTON	10	1	2	47.0	16.8		8.4	50	HSBT
WORKINGTON	48	1	2	68.0	22.3		13.3	135	HSBT
MARYPORT	2	1	2	65.8	21.3		12.5	118	SSBT
WORKINGTON	17	1	2	71.9	22.5		12.8	144	HSBT
WORKINGTON	19	1	2	70.7	21.8		13.3	134	HSBT
WHITEHAVEN	19	1	2	63.5	19.3		11.3	100	HSBT
MARYPORT	1	1	2	70.8	22.6		13.2	143	SSBT
MARYPORT	14	1	2	58.3	19.0		11.3	80	HSBT
WHITEHAVEN	37	1	2	65.3	20.4		12.3	111	HSBT
WORKINGTON	28	1	2	57.8	18.5		10.0	77	HSBT
WHITEHAVEN	24	1	2	60.3	17.7		9.0	81	HSBT
WORKINGTON	37	1	2	60.0	20.6		10.3	97	HSBT
WORKINGTON	7	1	2	69.0	22.0		13.3	134	HSBT
WHITEHAVEN	10	1	2	67.5	21.0		12.2	119	HSBT
WORKINGTON	4	1	2	62.8	19.1		12.3	93	SSBT
WORKINGTON	3	1	2	75.0	22.8		14.4	154	SSBT
WHITEHAVEN	18	1	2	53.0	16.5		9.0	57	HSBT
WORKINGTON	3	1	2	79.0	25.0		15.0	194	SSBT
WHITEHAVEN	1	1	2	72.0	22.6		14.3	145	SSBT
MARYPORT	14	1	2	65.0	22.3		12.3	131	HSBT
WORKINGTON	1	1	2	69.3	21.2		13.2	122	SSBT
NEWCASTLE	3	1	2	81.5	24.5		15.0	196	SSBT
WHITEYHAVEN	14	2	3	79.2	24.0	5.5		188	HSSN
WORKINGTON	2	1	2	68.0	22.8		13.6	146	SSBT
WHITEHAVEN	2	2	2	79.5	24.2	4.9		184	SSBT
MARYPORT	10	1	1	34.2	10.9		6.2	16	HSSP
MARYPORT	0	1	2	68.2	21.8		11.8	127	SSBT
WORKINGTON	23	1	2	64.4	21.1		11.8	112	HSBT
MARYPORT	6	1	2	71.3	23.3		14.2	147	SSBT
MARYPORT	0	1	2	51.5	16.8		8.5	59	SSBT
WHITEHAVEN	0	1	2	68.3	21.8		13.0	126	SSBT
WHITEHAVEN	0	1	2	80.7	24.0		15.2	188	HSBT
WORKINGTON	4	1	2	73.6	23.4		14.3	160	SSBT
WORKINGTON	0	1	1	46.3	14.2		8.2	36	SSSP
									L/B Ratio
AVERAGES	13.8			67.4	21.2	5.2	12.3	126.9	3.18
MEANS	12.5			68.6	21.8	5.2	12.7	129.5	3.15
GREATEST	48.0			98.4	27.6	5.5	18.8	300.0	3.57
LEAST	0.0			34.2	10.9	4.9	6.2	16.0	3.14

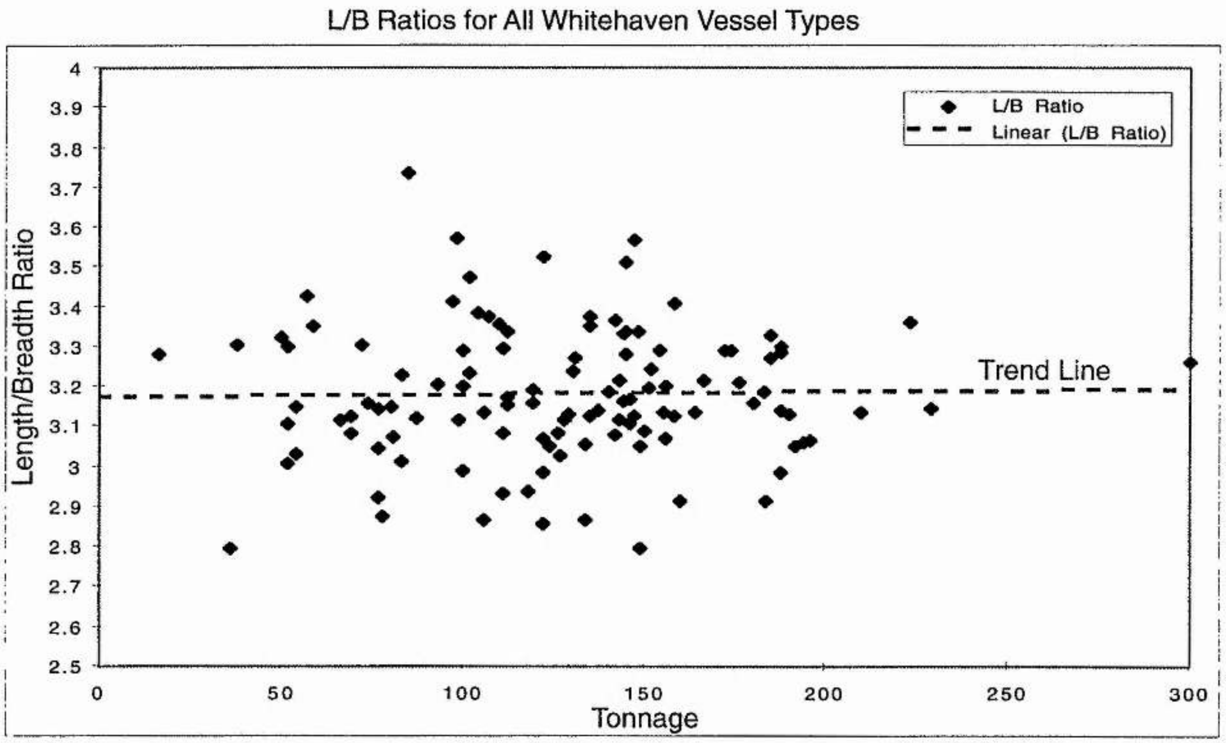
TABLE C.6
LENGTH-TO-BREADTH RATIOS
DETERMINED FROM THE PORT REGISTRIES, 1786-87

Port	Mean	Average	Greatest	Least	Notes
London	2.98	3.00	4.11	2.29	1
Newcastle	3.55	3.58	4.22	2.65	2
Whitby	3.47	3.52	4.78	2.82	3
Whitehaven	3.18	3.16	3.73	2.80	4

NOTES:

1. The greatest value is for a barge; the next largest value is 3.68.
2. Values, many quite large, cover the whole range.
3. The greatest value is almost certainly a recording error, since the next largest value is 3.76.
4. Values cover the whole range.

As shown in Figure C.1 (next page), there is no apparent trend or standardization in the length/breadth ratios for vessels taken as a whole; more strikingly is the lack of any standardization even among vessels listed as being of the same type. Although only one type of vessel from one port was graphed here, others were checked, with the same result.



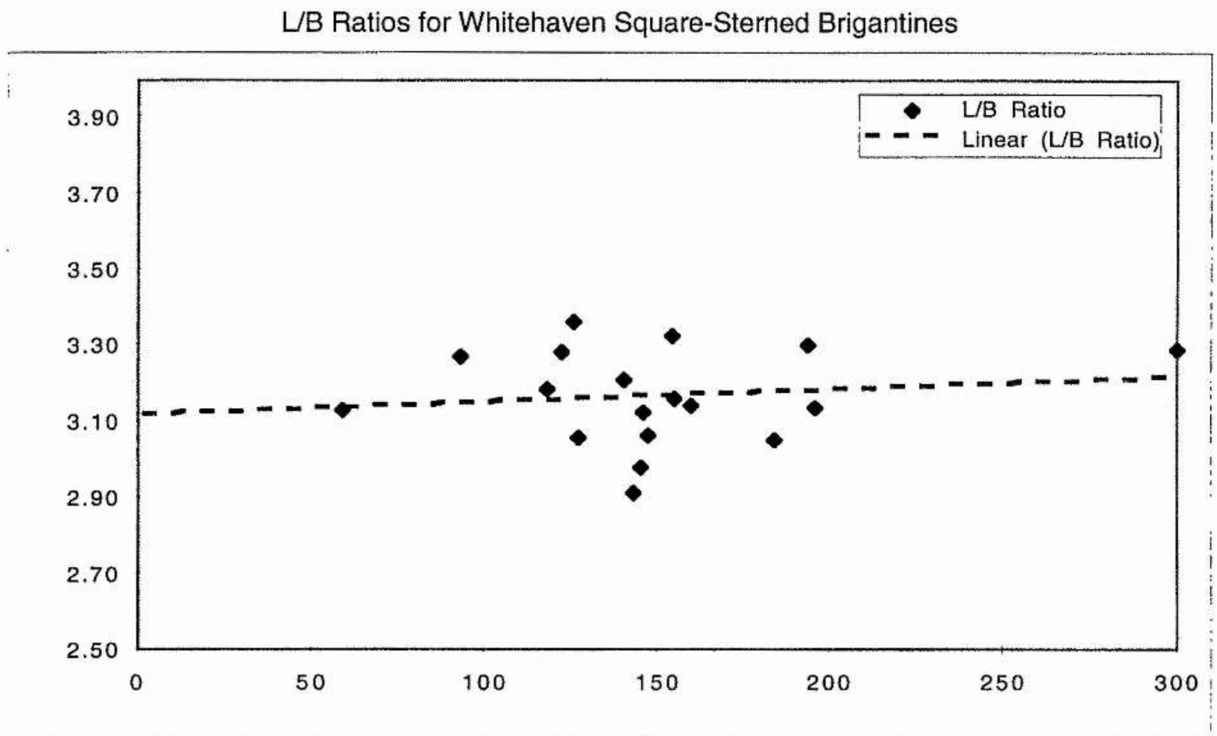


Figure C.1. Port of Whitehaven: Plot of L/B Ratio for all vessels, above, and for only the square-sterned brigantines (SSBT), below, showing lack of standardization.

DIMENSIONS OF VESSELS BUILT BY THE TINDALL SHIPBUILDING FIRM DURING THE 1770s

The graph below shows the length/breadth ratios and breadth/depth ratios for a series of vessels built by the Tindall Shipbuilding Firm of Scarborough during the 1770s. It will be seen that even the vessels built by a single yard during a single decade exhibited a wide variance in their dimensions and ratios. Most of these vessels were ships or brigs.

The same pattern held true for Tindall vessels built during the 1790s, but the vessels tended to be slightly less beamy (larger length/breadth ratios).

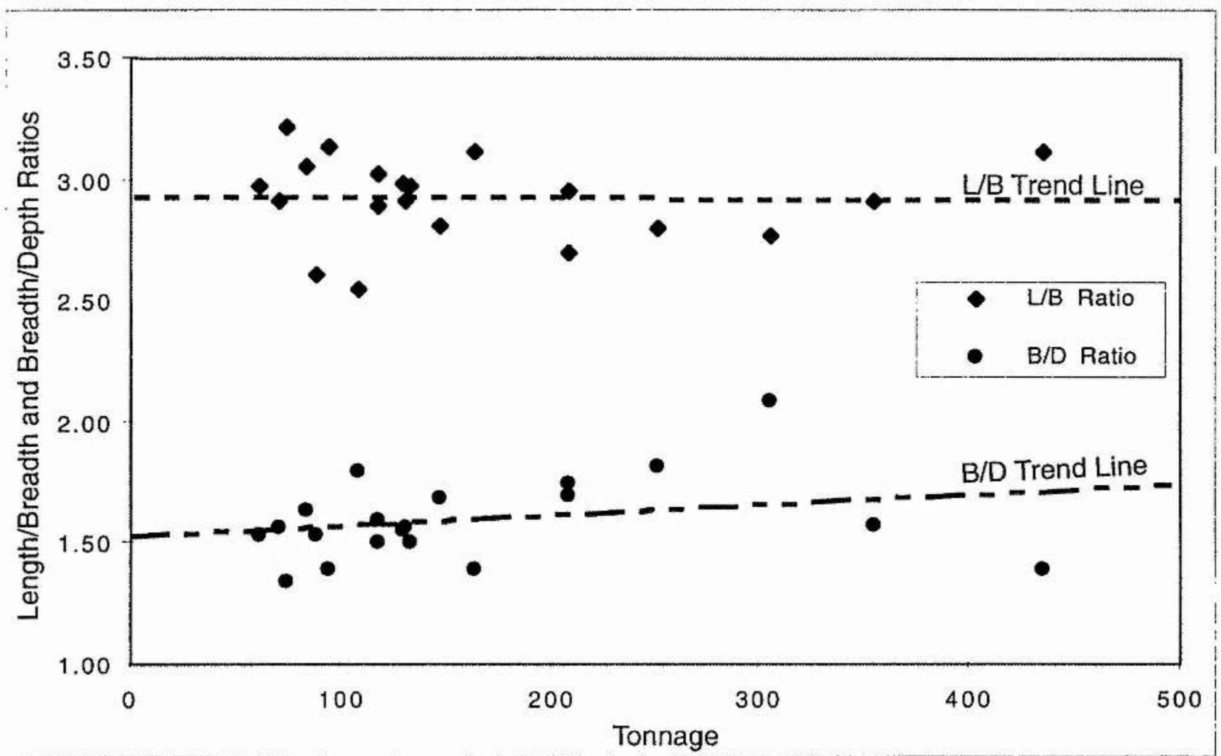


Figure C.2. Vessels Built by the Tindall Shipbuilding Firm during the 1770s: Plot of L/B Ratio and B/D Ratio for all vessels, showing lack of standardization.

Lloyd's Register of Shipping

Whereas the Customs House Port Registry, discussed previously, was generated in response to a statutory requirement, *Lloyd's Register of Shipping* is a voluntary registry, originally established by an informal group of influential underwriters, shipping agents and ship owners who met at Lloyd's Coffee House in London (Brown 1973). The Customs House registers were maintained for the purposes of establishing title, origin and ownership, and for determining customs asseessment rates, while *Lloyd's Register of Shipping* listed insured merchant vessels and classified them according to value and condition for marine insurance purposes. *Lloyd's Register* listed all vessels, foreign and domestic, that had been inspected, classified and insured by Lloyd's surveyors. *Lloyd's Register*, therefore, contains information on some vessels that are not of interest to this study. Simple random selection was used in compiling the following tables.

TABLE C.7
SAMPLING OF ENTRIES FROM *LLOYD'S REGISTER OF SHIPPING*, 1764

Vessel Name	Ton-nage	Decks/ Guns	Place Blt	Age	Lloyd's Rating
Albion	110	S d S L	Hull	1	AG AM
Albion	170	S d B	Hull	3	AM
Alexander	250		River	13	EM
Alexander	305	2 3	River	6	AM
Amity's Adventure	450	S D B	Scarborough	2	AM
Anglicana	350	16 6	Liverpool	6	AM
Ann	160		Topsham	2	
Ann & Betty	100	S d S L	Portsmouth	14	EM
Ann & Mary	90	S d B	Yarmouth	8	EM
Antonetta	305		River	2	AG
Ashley	250	s	Hull	12	EM
Antelope	350	S D B	Whitby	7	EM
Bacchus	130	B	Isle of Wight	10	EM
Baltic Merchant	200		River	13	EM
Beaufain	200	2 3	Rochester	1	AG
Ben	110	S d B	Whitehaven	15	AG
Betsey	80	S d	Pool	9	EM
Diamond	300	W	River	13	
Diana	120	S d b B	Whitby	9	EM
Dispatch	90	S d B	Yarmouth	19	
Dolphin	160	S d b B	Yarmouth	10	EM
Dorothy & Esther	330	S d B	Whitby	15	EM
Fanny	375	s 3 decks	River	1	AG
Fanny & Betsy	70	s B	Pool	27	EG EM
Favourite Betsey	300	6-3 3Ds	River	0	AG
Flora	180		Pool	1	AG
Harding	120	S d B	Bristol	6	
Harmony	150		Whitehaven	1	AG
Harrison	370	s 6 4	River	14	EM
Jenny	30	S L	British	4	EM
Jenny	360	S d b	Hull	14	EM
Industry	120		Yarmouth	3	AG
John & Bella	168		Cumberland	4	AG
Magdalen	140	S d B	Hull	1	AG
Mark Anthony	100		British	15	EM
Martha	120	B	River	14	EM
Martin	250	S d b	Stockton	1	AG
Olive	202	s	Whitehaven	15	EM
Ocean	200	S D B	Whitby	1	
Olive Branch	160	S D B B	Lyn	2	AG
Onslow	120	S D B	Milford	13	EC
Rachel	100	S d B	Yarmouth	1	AG
Resolution	220	S d B	Stockton	14	EM
Richard	30		British	13	IM
Tagus	160		River	10	EM
Thetis	200	s	River	14	EM

(continued)

Lloyd's Register, 1764 (cont.)

Vessel Name	Ton-nage	Decks/ Guns	Place Blt	Age	Lloyd's Rating
Thomas & Ann	140	S D	Biddeford	8	
Thos. & Mathew	90	S d S L	Ipswich	5	EG
Thornton	400	S d B	Stockton	2	AG
Wm. & Mary	70	S D S L	Ipswich	9	EM
Williamson	240		Hull	0	AG
Wm. & Mary	140	SDBB	Lynn	22	EM
Wm. & Mary	450	SDB	Whitby	3	AG
York	475	S d B	Whitby	6	
Young Spencer	120	S d B	Yarmouth	12	EG AM
Zach.Baily	305	s 10 4	Whitehaven	7	EM
AVERAGE	202			8	
MEDIAN	168			8	
GREATEST	475			27	
LEAST	30			0	

TABLE C.8
SAMPLING OF ENTRIES FROM *LLOYD'S REGISTER OF SHIPPING*, 1800

Vessel Name	Tonnage	Type	Decks	Place Blt	Age	Lloyd's Rating	Comments
Abby	144	Bg	SDB	Lancaster	13	E1	
Achilles	296	S	SDB	Whitby	36	I.1.	
Active	156	S		Bristol	1	A1	cu-sheathed
Active	108	Bg	SDB	Yarmouth	9	A1	
Active	163	Bg	SDB	Hull	3	A1	
Active	81	Bg	SD	Yarmouth	23	I.1	
Active	66	Sp	SD	Plymouth	5	A1	
Acton	202	Bg	SDB	Lynn	38	I.1	
Adelphi	337	S	SDB	Shields	5	A1	
Adeona	200	Bg	SDB	Whitby	3	A1	
Bacchus	100	Bg	SDB	Newcastle	31	I.1	
Backhouse	286	S		Hull	1	A1	sh w/cu over bds
Barbados Friends	253	S		Chester	8	A1	sh w/cu over bds
Barrick	252	S	SDB	Whitby	9	A1	sh
Basseterre	300	S		River	25	I.1	sh
Beckford	84	Bg	SD	Yarmouth	19	I.1	doubled
Bell	224	Bg	SDB	Sunderland	6	A1	
Bellona	243	S	SDW	Lancaster	1	A1	cu-sh
Bellona	364	S		Whitby	6	A1	
Camperdown	355	S		Whitby	2	A1	sh
Carlisle	234	Bg	SDB	Whitehaven	17	E1	sh
Caroline	147	Bg	SD	Newcastle	5	A1	sh
Castor	467	S		Whitehaven	18	I.1	sh w/cu over bds
Catharine	214	Bg	SDB	Newcastle	9	A1	
Diana	79	S	SDB	Greenock	2	A1	cu-sh
Diana	147	Bg	SDB	Sunderland	2	A1	
Dick	63	Sp	SD	Chester	6	A1	
Diligence	149	Sw	SDB	Liverpool	36	I.1	doubled
Diligent	56	Sp	SD	Milford	7	A1	
Eliza	154	Bg	SDB	Whitby	5	A1	
Elizabeth	126	Bg	SDB	Chester	9	A1	
Elizabeth	237	S		Bristol	11	A1	sh
Emerald	281	S		Newcastle	11	E1	cu-sh
Endeavour	112	Bg	SDB	Scarborough	14	E1	
Fidelity	208	Bg	SDB	Scarborough	6	A1	
Fingal	163	Sw	SDB	Leith	5	A1	
Fletcher	216	S	SDB	Maryport	4	A1	
Flora	327	S	SDB	Hull	10	A1	part. cu-sh
Flora	92	Bg	SD	Yarmouth	8	A1	

(continued)

Lloyd's Register, 1800 (cont.)

Vessel Name	Ton-nage	Type	Decks	Place Blt	Age	Lloyd's Rating	Comments
Good Intent	61	Sp	SD	Chester	9	A1	
Good Intent	186	S	SDB	Scarborough	41	I.1	sh & dbld
Good Vennrs	138	Bg	SDB	Yarmouth	4	A1	
Grace	112	Bg	SDB	Workington	7	A1	
Grand Duke	243	S	DW	Ipswitch	15	E1	cu-sh
Hercules	322	S		Bristol	4	A1	sh
Hero	180	Sw	SDB	Workington	12	E1	sh
Heslewood	128	Bg	SDB	Hull	1	A1	
Hibernia	32	Sp	SD	Bristol	8	A1	cu-sh
Hiram	223	Bg	SDB	Sunderland	14	E1	sh
Integrity	299	S	SDB	Whitby	9	A1	
Inverness	84	Sp	SD	river	15	E1	
John	358	S		Whitby	2	A1	sh
John	163	Bg	SDB	Lynn	14	E1	
Kate	241	S		Liverpool	1	A1	cu-sh
Kent	392	S		Newcastle	5	A1	sh
King George	290	S		Newcastle	16	I	transport
King George	300	S		River	17	E1	sh
Kingston	284	S	SDB	Hull	1	A1	
Lord Nelson	250	S		Liverpool	2	A1	cu-sh
Lord Rodney	455	S	3Ds	River	18	E1	cu-sh&i.b. ovr
bds							
Love	231	S	SDB	Whitehaven	9	A1	sh
Montgomery	183	S		Whitehaven	1	A1	cu-sh
Morning Star	83	Bg	SD	Leith	4	A1	
Musgrave	219	Sw	SDB	Maryport	7	A1	sh
Nancy	75	Sp	SD	Northumberland	7	A1	
Nancy	145	Sw	SDB	Hull	15	E2/E1	
Orford	322	Sw	SDB	Shields	4	A1	
Orwell	350	S	SDB	Whitby	46	I.1	dbld
Orion	221	Bg		Sunderland	4	A1	
Perseverance	305	Bg		Whitby	18	E1	
Perseus	364	S		Stockton	1	A1	
Philip & Mary	106	Bg	SDB	Maryport	15	E1	
Resource	148	Sw	SDB	Newcastle	6	A1	
Richard	319	S	SDW	Lancaster	1	A1	

(continued)

Lloyd's Register, 1800 (cont.)

Vessel Name	Tonnage	Type	Decks	Place Blt	Age	Lloyd's Rating	Comments
Trial	130	Bg	SD	Newbury	7	A1	
Trinity Buoy	118	Y Sw	SD	River	11	A1	
Triton	119	Bg	SDB	Whitehaven	29	I.1	
Valentine	112	Bg	SDB	Cheapstowe	22	I.1	
Van Guard	300	S		Liverpool	1	A1	
Venture	106	Bg	SDB	Hull	9	A1	
Venus	221	S		Leith	3	A1	
AVERAGE	205				11		
MEDIAN	205				8		
GREATEST	467				46		
LEAST	32				1		

APPENDIX D

Measured and Computed Attributes for a Variety of Merchant Vessels

Contents

Vessels Described in this Study

Specifications for a Variety of Vessels

Coefficients for a Variety of Vessels

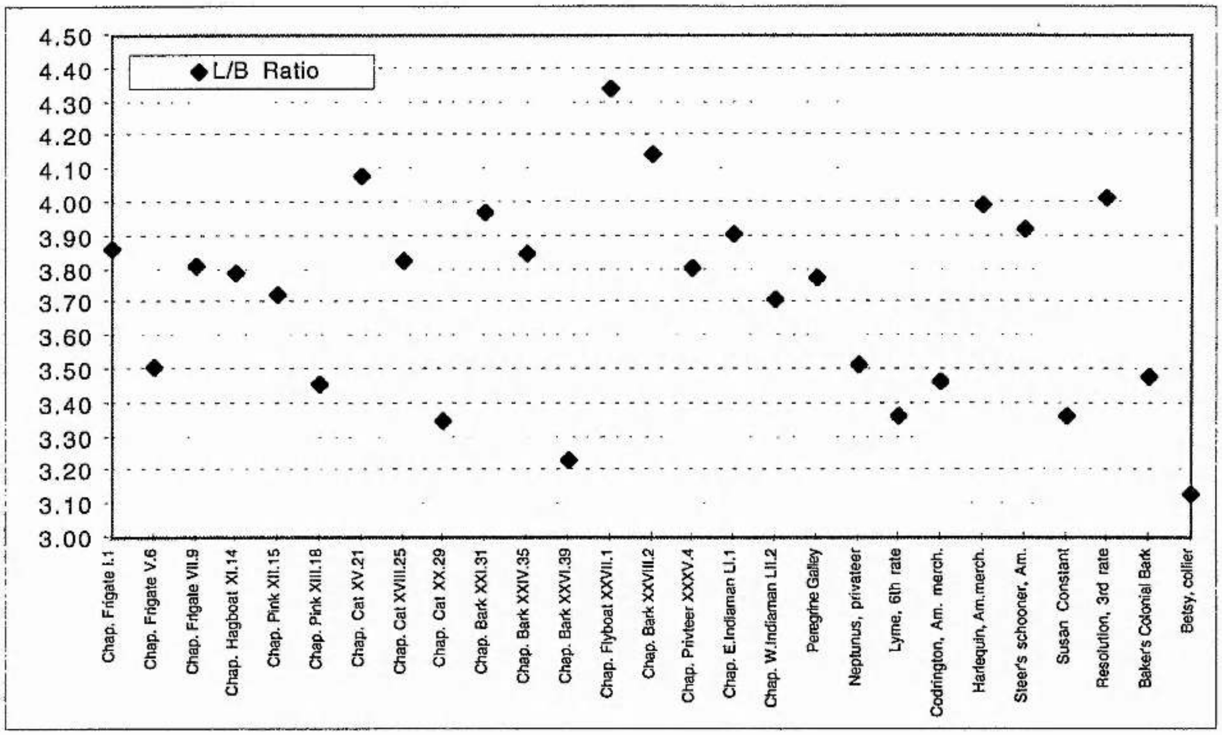
Length-to-Breadth Ratios for Various Vessels

TABLE D.1
PARTIAL LIST OF VESSELS ANALYZED IN THIS STUDY

Vessel Name, or Plate/Dwg. No.	Type of Rig	Date	Tons, B.O.M.	Source	Comments
Chap. Frigate I.1	Ship	1768	1277	Chapman 1768:Plate I.1	"Merchant vessel, first class"
Chap. Frigate V.6	Ship	1768	358	" Pl. V.6	"
Chap. Frigate VII.9	Schooner	1768	127	" Pl. VII.9	"
Chap. Hagboat XI.14	Ship	1768	582	" Pl. XI.14	"Merchant vessel, second class"
Chap. Pink XII.15	Ship	1768	434	" Pl. XII.15	"Merchant vessel, third class"
Chap. Pink XIII.18	Brig	1768	161	" Pl. XIII.18	"
Chap. Cat XV.21	Ship	1768	1119	" Pl. XV.21	"Merchant vessel, fourth class"
Chap. Cat XVIII.25	Ship	1768	458	" Pl. XVIII.25	"
Chap. Cat XX.29	Sloop	1768	108	" Pl. XX.29	"
Chap. Bark XXI.31	Ship	1768	1249	" Pl. XXI.31	"Merchant vessel, fifth class"
Chap. Bark XXIV.35	Ship	1768	436	" Pl. XXIV.35	"
Chap. Bark XXVI.39	Sloop	1768	84	" Pl. XXVI.39	"
Chap. Flyboat XXVII.1	Ship	1768	700	" Pl. XXVII.1	"Vessels, small draugt of water"
Chap. Bark XXVIII.2	Ship	1768	458	" Pl. XXVIII.2	"
Chap. Privteer XXXV.4	Ship	1768	470	" Pl. XXXV.4	"Privateer, frigate"
Chap. E.Indiaman LI.1	Ship	1768	753	" Pl. LI.1	"An English East Indiaman"
Chap. W.Indiaman LII.2	Ship	1768	336	" Pl. LII.2	"An English West India trader"
Peregrine Galley	Ship	1700	207	Chapelle 1967:37	English galley ship, fast sailer
Neptunus, privateer	Ship	1720	186	" p. 74	Built Ostend, very fast sailer
Lyme, 6th rate	Ship	1739	430	" p. 63	24-gun galley ship, "fast" lines
Codrington, Am. merch.	Ship	1774	173	" p. 110	Amer.-built, typical English form
Harlequin, Am.merch.	Ship	1780	151	" p. 106	American built, sharp lines
Steer's schooner, Am.	Schooner	1805	226	" p. 193	English-built on American form
Susan Constant	Bark	1605	178	Lavery 1988:lines plan	Merchant bark (reconstructed)
Resolution, 3rd rate	Ship	1667	1083	Lavery 1981:124	English warship (reconstructed)
Baker's Colonial Bark	none	1640	39	Baker 1962:lines plan	Small colonial bark (reconstructed)
Betsy, collier	**Brig**	**1772**	**176**	[This study]	English collier (described herein)

TABLE D.2
SPECIFICATIONS FOR A VARIETY OF VESSELS
(Note: See previouspage for descriptions of the vessels)

Vessel Name, or Plate/Dwg. No.	Type Rig	Date	Length Between Perpend.	Breadth Molded	Tons, B.O.M.	L/B Ratio	Mid-Ship Coeff.	Block Coeff.	Pris-matic Coeff.	Water line Coeff.	Fwd. Fine. Coeff.	Aft Fine. Coeff.	Hull Fine. Coeff.
Chap. Frigate I.1	Ship	1768	159.80	41.41	1277	3.86	0.87			0.85	0.64	0.46	0.55
Chap. Frigate V.6	Ship	1768	100.70	28.74	358	3.50	0.81			0.85	0.55	0.45	0.50
Chap. Frigate VII.9	Schnr	1768	79.90	20.95	127	3.81	0.86			0.80	0.58	0.42	0.50
Chap. Hagboat XI.14	Ship	1768	121.80	32.16	582	3.79	0.85			0.83	0.64	0.43	0.54
Chap. Pink XII.15	Ship	1768	110.10	29.55	434	3.73	0.82			0.87	0.63	0.48	0.55
Chap. Pink XIII.18	Brig	1768	75.00	21.68	161	3.46	0.78			0.83	0.56	0.41	0.49
Chap. Cat XV.21	Ship	1768	153.00	37.51	1119	4.08	0.92			0.89	0.69	0.48	0.58
Chap. Cat XVIII.25	Ship	1768	107.20	28.01	458	3.83	0.86			0.89	0.70	0.52	0.61
Chap. Cat XX.29	Sloop	1768	60.40	18.03	108	3.35	0.83			0.92	0.66	0.45	0.55
Chap. Bark XXI.31	Ship	1768	151.00	38.00	1249	3.97	0.90			0.94	0.76	0.53	0.64
Chap. Bark XXIV.35	Ship	1768	104.30	27.12	436	3.85	0.87			0.90	0.70	0.54	0.62
Chap. Bark XXVI.39	Sloop	1768	57.49	17.78	84	3.23	0.83			0.94	0.66	0.45	0.56
Chap. Flyboat XXVII.1	Ship	1768	128.90	29.72	700	4.34	0.90			0.92	0.75	0.63	0.69
Chap. Bark XXVIII.2	Ship	1768	109.10	26.31	458	4.15	0.91			0.94	0.78	0.61	0.70
Chap. Privteer XXXV.4	Ship	1768	125.20	32.89	470	3.81	0.74			0.85	0.48	0.37	0.43
Chap. E.Indiaman LI.1	Ship	1768	132.00	33.78	753	3.91	0.89			0.94	0.72	0.56	0.64
Chap. W.Indiaman LII.2	Ship	1768	99.40	26.80	336	3.71	0.89			0.95	0.75	0.51	0.63
Peregrine Galley	Ship	1700	86.25	22.83	207	3.78	0.81	0.51	0.65	0.84	0.49	0.36	0.43
Neptunus, privateer	Ship	1720	79.67	22.67	186	3.92	0.71	0.44	0.62	0.79	0.43	0.19	0.31
Lyme, 6th rate	Ship	1739	106.00	30.00	430	3.53	0.74	0.49	0.66	0.84	0.47	0.38	0.43
Codrington,Am.merch.	Ship	1774	77.10	22.25	173	3.47	0.87	0.60	0.71	0.87	0.68	0.44	0.56
Harlequin, Am.merch.	Ship	1780	80.25	20.10	151	3.99	0.67	0.45	0.63	0.84	0.50	0.14	0.32
Steer's schooner, Am.	Schnr	1805	90.83	23.17	226	3.92	0.60	0.36	0.59	0.72	0.37	0.12	0.24
Susan Constant	Bark	1605	76.50	22.75	178	3.36	0.80			0.85	0.52	0.41	0.47
Resolution, 3rd rate	Ship	1667	156.00	38.85	1083	4.02	0.79			0.77	0.46	0.28	0.37
Baker's Colonial Bark	none	1640	46.75	13.45	39	3.48	0.85			0.85	0.56	0.44	0.50
Betsy, collier	**Brig**	**1772**	**73.14**	**23.35**	**176**	**3.13**	**0.87**			**0.88**	**0.77**	**0.51**	**0.64**



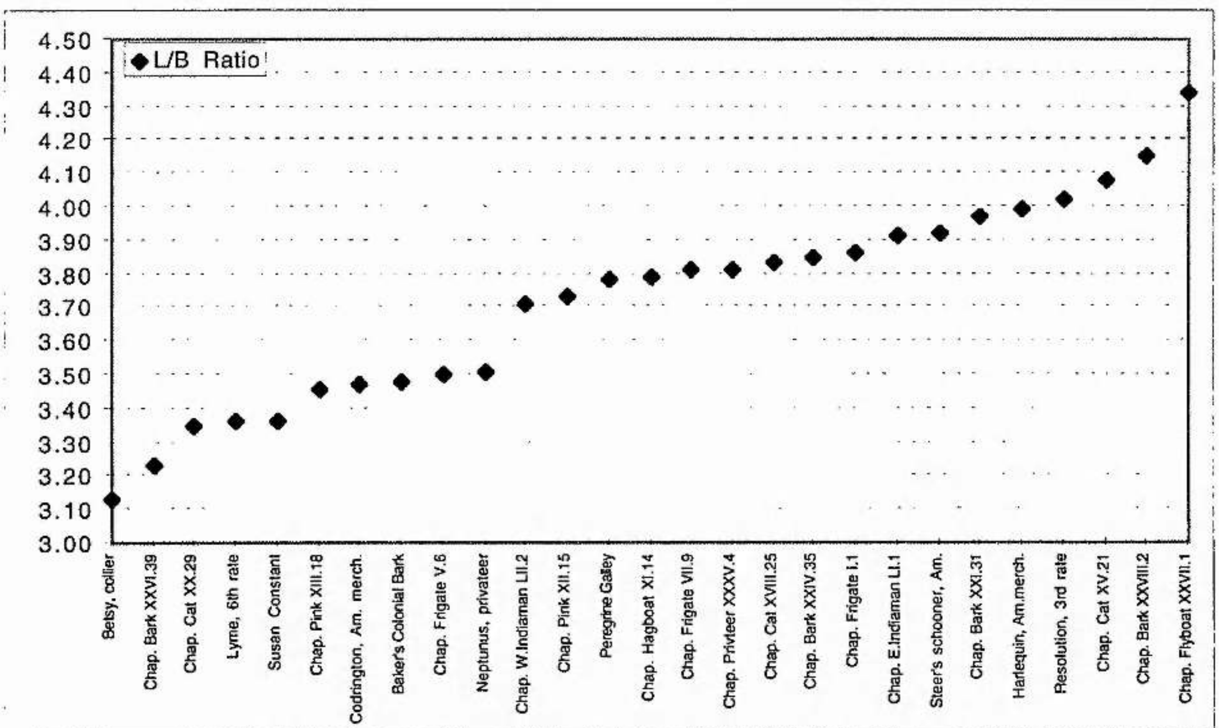


Figure D.1. Length-to-Breadth (L/B) Ratios for a variety of vessels:
(top) Listing by vessel type (see tables D.1 and D.2)
(bottom) Listing sorted by magnitude of L/B ratio

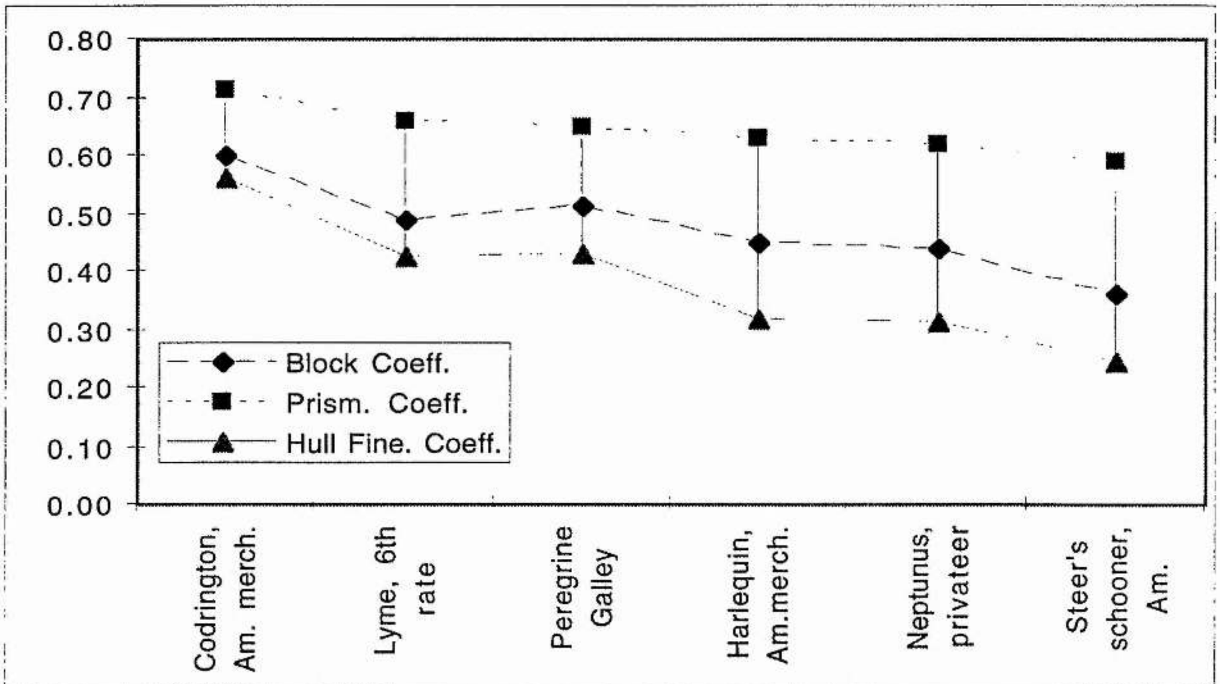


Figure D.2. Comparison of standard block and prismatic coefficients with the hull fineness coefficient developed for this study; it will be noted that the coefficients for the full-bodied merchant vessel Codrington *easily identify the vessel as slower than the others.*

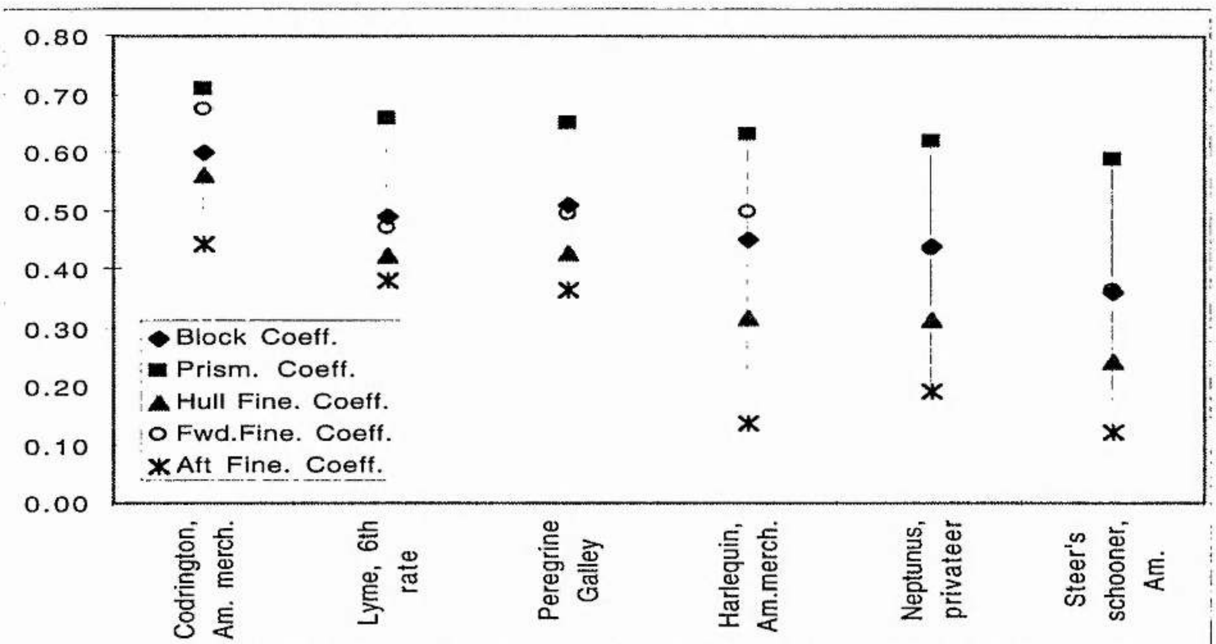


Figure D.3. Comparison of standard block and prismatic coefficients with the fineness coefficients (forward, aft and hull) developed for this study; the relative consistency of these coefficients is evident.

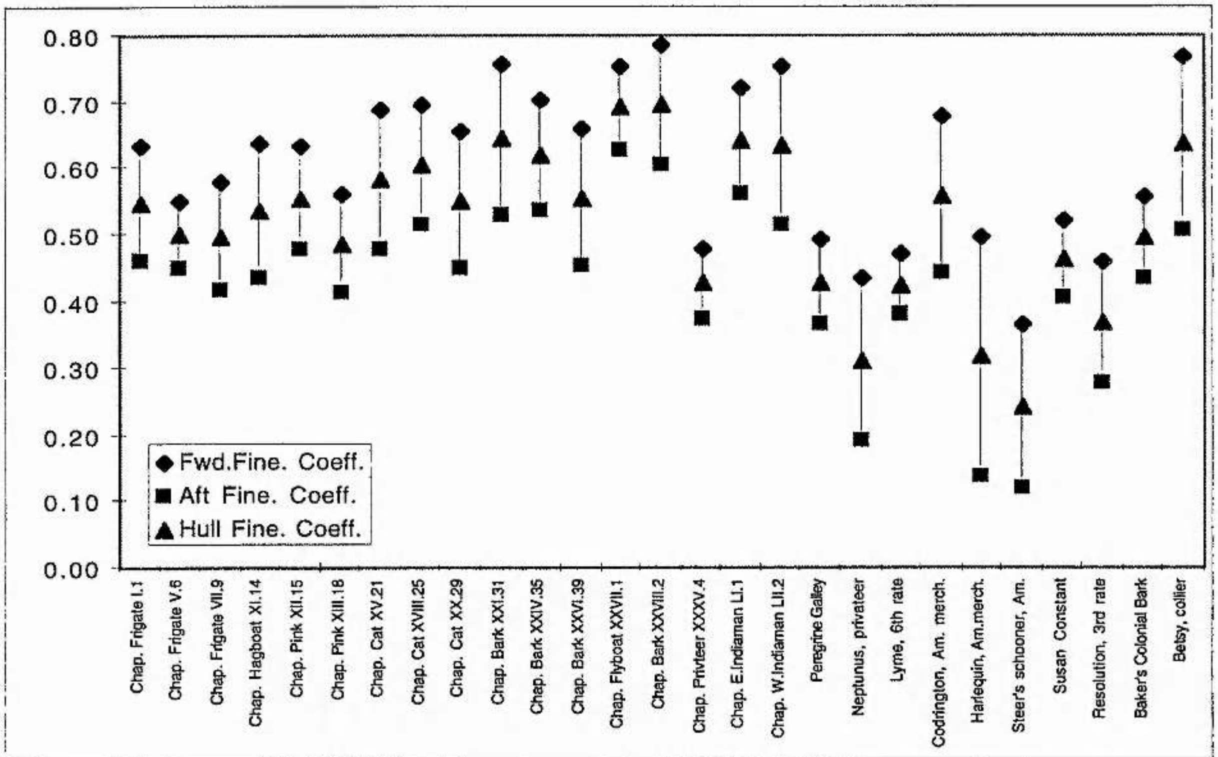


Figure D.4. Fineness coefficients (forward, aft and hull) for a variety of vessels examined in this study.

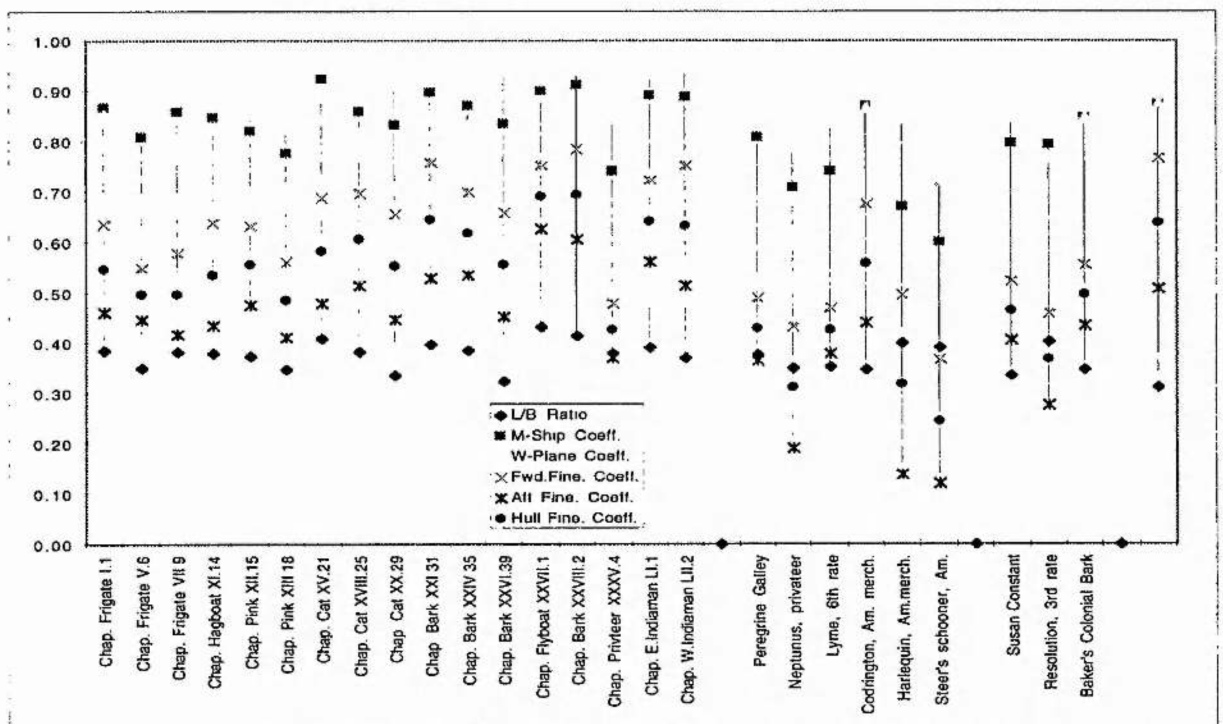


Figure D.5. All dimensionless coefficients for a variety of vessels examined in this study.

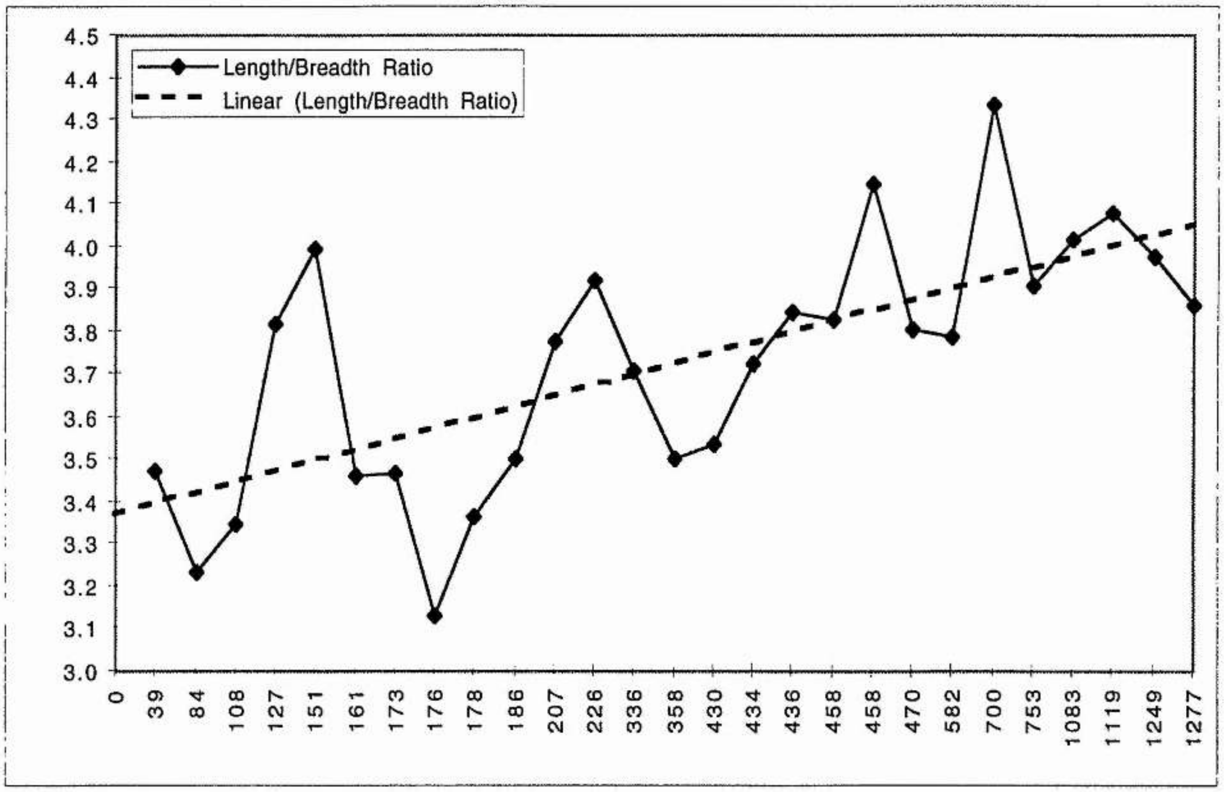


Figure D.6. Tonnage versus L/B ratio for a variety of vessels examined in this study.

APPENDIX E

Merchant Vessel Masting and Rigging

Contents

Mast Positions for a Variety of Vessels

Mast and Midships Frame Positions for Four Rigs

An Analysis of Vessels Masted by the Smales Firm

A Compariston of the Rigs of Brigs from Various Sources

TABLE E.1
MAST POSITIONS FOR A VARIETY OF VESSEL TYPES

NAME OR CHAPMAN PLATE NUMBER	BURTHEN (TONS)	DIST. FROM STERN PERPENDICULAR (IN %) MAINMAST	FOREMAST	MIDSHIP BEND
SNOWS:				
VI. No. 8, frigate	170.4	37.9	85.2	56.8
XII. No. 17, pink	237.6	37.1	85.0	56.7
XIX. No. 27, cat	237.6	37.1	84.5	57.3
XXV. No. 36, bark	314.4	37.7	85.3	58.5
XXVIII. No. 3, bark(sd)	309.6	37.6	86.1	57.4
Duchess of Manchester	137.0	39.7	84.4	65.2
BRIGS:				
XIII. No. 18, pink	160.8	36.1	84.4	56.8
XIV. No. 19, pink	96.0	36.0	84.2	56.6
XX. No. 28, cat	160.8	36.9	84.3	57.7
XXV. No. 37, bark	213.6	36.8	87.0	57.4
XXVI. No. 38, bark	136.8	37.1	85.9	59.2
XXIX. No. 7, bark(sd)	156.0	36.8	85.2	56.9
Duchess of Manchester	137.0	34.1	84.4	65.2
Industry	222.0	38.4	85.1	52.7
Steel's Collier Brig	170.0	39.7	85.8	61.7
Am. brig, 1775 (Davis)		34.0	83.4	
Danish syst,1775(Davis)		37.5	83.4	
French syst,1775(Davis)		35.0	79.0	
SCHOONERS:				
VII. No. 9, frigate	127.2	34.2	77.0	56.2
XXVII. No. 4, bark(sd)	182.4	35.2	78.6	57.5
Schooner for Pt. Jackson	60.0	38.7	84.1	56.7
Sea Lark (very sharp)	178.0	40.5	82.3	59.7
SHIPS:				
VI. No. 8, frigate	252.0	43.7	87.8	57.0
XII. No. 16, pink	331.2	43.2	86.6	56.5
XIX. No. 26, cat	340.8	43.2	88.9	58.0
XXVIII. No. 2, bark(sd)	458.4	43.3	87.3	58.5
Earl of Pembroke	368.0	43.2	86.6	56.7
Exeter	267.0	44.2	85.0	57.7
Am. Rule, 1-4-6 (Davis)		42.9	85.7	

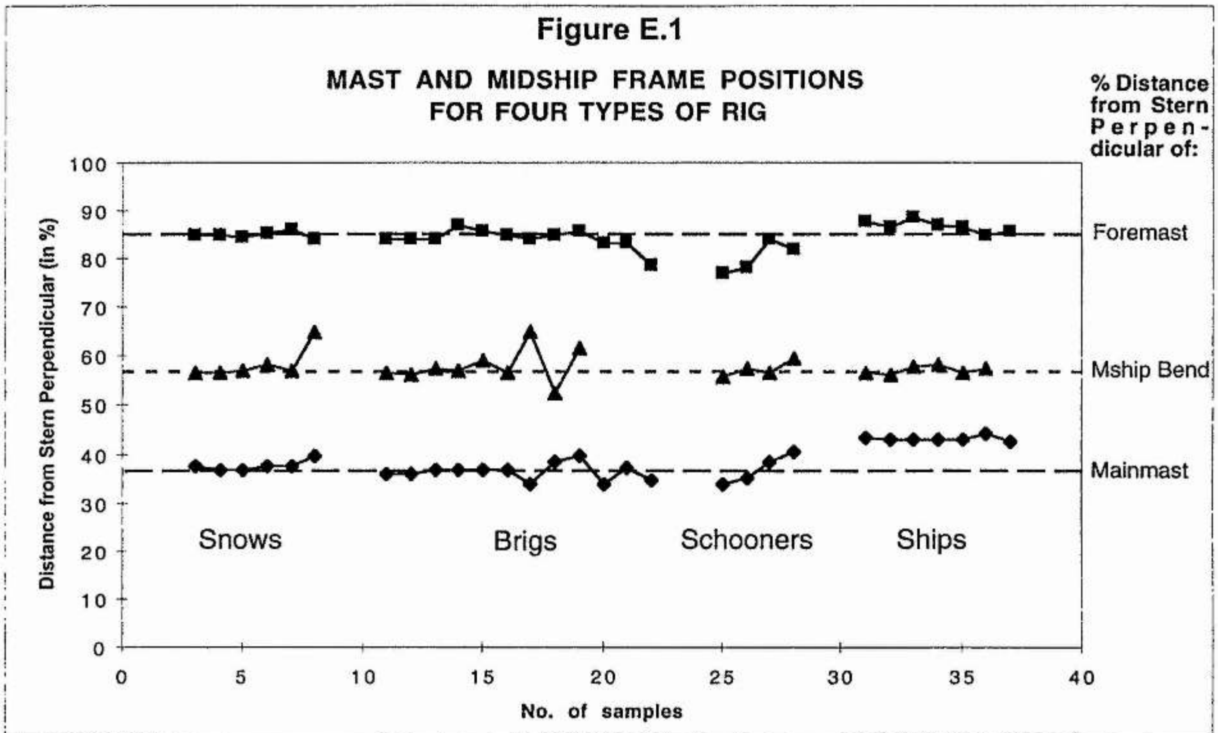


TABLE E.2
AVERAGE MAST POSITIONS FOR A VARIETY OF VESSEL TYPES

VESSEL TYPE	BURTHEN (TONS)	DIST. FROM STERN PERPENDICULAR (IN %) MAINMAST	FOREMAST	MIDSHIP BEND
SNOWS (CHAPMAN)	253.9	37.5	85.2	57.3
(MACGREGOR)	137.0	39.7	84.4	65.2
BRIGS (CHAPMAN)	154.0	36.6	85.2	57.4
(MACGREGOR)	176.3	37.4	85.1	59.9
(DAVIS)		35.5	81.9	
SCHOONERS (CHAPMAN)	154.8	34.7	77.8	56.9
(MACGREGOR)	119.0	39.6	83.2	58.2
SHIPS (CHAPMAN)	345.6	43.4	87.7	57.5
(MACGREGOR)	317.5	43.7	85.8	57.2
(DAVIS, 1-4-6)		42.9	85.7	
SHIPWRECK 44YO88	180.0	41.4	85.3	60.2?

TABLE E.3: MASTING DETAILS FOR TEN SMALES BRIGS

	NANCY	MCFRTH's	BRITANNIA	WKNSON's	JCKSON's	IBETSON	FAME	HEBE	CHOICE	THETIS	Averages
Length	71.00	82.00	75	70.00	64.00	64.00	64.00	62.00	70.00	67.70	**68.97**
Beam	23.00	26.00	25	22.50	22.50	22.00	22.00	21.00	24.00	23.30	**23.13**
Tonnage-given	254		187				68	128	202	183	**170**
Tonnage-BOM	161	239	199	152	136	131	131	116	170	155	**159**
L/B Ratio	3.09	3.15	3.00	3.11	2.84	2.91	2.91	2.95	2.92	2.91	**2.98**
Date Built	1767	1770	1772	1775	1784	1786	1787	1789	1790	1806	**1782.6**
Mainmast	63.00	72.00	67.00	62.00	54.00	55.00	52.00	51.50	56.00	56.00	**58.85**
Main Yard	39.00	43.00	40.00	36.00	34.00	34.00	33.00	33.00	36.00	38.00	**36.60**
Main Topmast	32.00	35.00	33.00	24.00	28.00	28.50	27.00	27.00	31.00	31.50	**29.70**
MT Yard	31.00	36.00	32.00	27.00	26.00	27.00	26.00	25.00	28.00	28.00	**28.60**
Main T'gallnt	16.00	18.00	16.00	16.00	20.00	15.00	14.50	14.00	15.50	15.00	**16.00**
MTG Yard	18.00	29.00	26.00	18.00	0.00	20.00	20.00	18.00	21.00	18.00	**20.89**
Main Boom	42.00	45.00	42.00	44.00	36.00	38.00	36.00	36.00	38.00	40.00	**39.70**
Main Gaff	23.00	24.00	22.00	0.00	21.00	21.00	21.00	20.00	24.00	27.00	**22.56**
Foremast	55.00	62.00	59.00	53.00	47.00	49.00	47.00	46.00	51.00	52.00	**52.10**
Fore Yard	31.00	43.00	40.00	36.00	34.00	34.00	33.00	33.00	36.00	38.00	**35.80**
Fore Topmast	32.00	35.00	33.00	30.00	28.00	28.50	27.00	27.00	31.00	31.50	**30.30**
FT Yard	31.00	36.00	32.00	27.00	26.00	27.00	26.00	25.00	28.00	28.00	**28.60**
Fore T'gallnt	15.00	18.00	16.00	16.00	14.00	15.00	14.50	14.00	15.50	15.00	**15.30**
FTG Yard	7.00	29.00	26.00	18.00	0.00	20.00	20.00	18.00	21.00	18.00	**17.70**
Bowsprit	35.00	40.00	38.00	35.00	33.00	34.00	36.00	31.00	34.00	34.00	**35.00**
BS Yard	31.00	36.00	0.00	27.00	0.00	0.00	0.00	0.00	0.00	0.00	**31.33**
Jib Boom	0.00	30.00	28.00	29.00	26.00	26.00	24.00	23.00	28.00	0.00	**21.40**
RATIOS											
> Mainmast/Beam	2.74	2.77	2.68	2.76	2.40	2.50	2.36	2.45	2.33	2.40	**2.54**
MYard/MMast	0.62	0.60	0.60	0.58	0.63	0.62	0.63	0.64	0.64	0.68	**0.62**
MTM/MM	0.51	0.49	0.49	0.39	0.52	0.52	0.52	0.52	0.55	0.56	**0.51**
MTMYd/MTM	0.97	1.03	0.97	1.13	0.93	0.95	0.96	0.93	0.90	0.89	**0.96**
MTGM/MTM	0.50	0.51	0.48	0.67	0.71	0.53	0.54	0.52	0.50	0.48	**0.54**
MTGMYd/MTGM	1.13	1.61	1.63	1.13	0.00	1.33	1.38	1.29	1.35	1.20	**1.20**
> Foremast/MMast	0.87	0.86	0.88	0.85	0.87	0.89	0.90	0.89	0.91	0.93	**0.89**
FYard/Fmast	0.56	0.69	0.68	0.68	0.72	0.69	0.70	0.72	0.71	0.73	**0.69**
>Bowsprt/MM	0.56	0.56	0.57	0.56	0.61	0.62	0.69	0.60	0.61	0.61	**0.60**

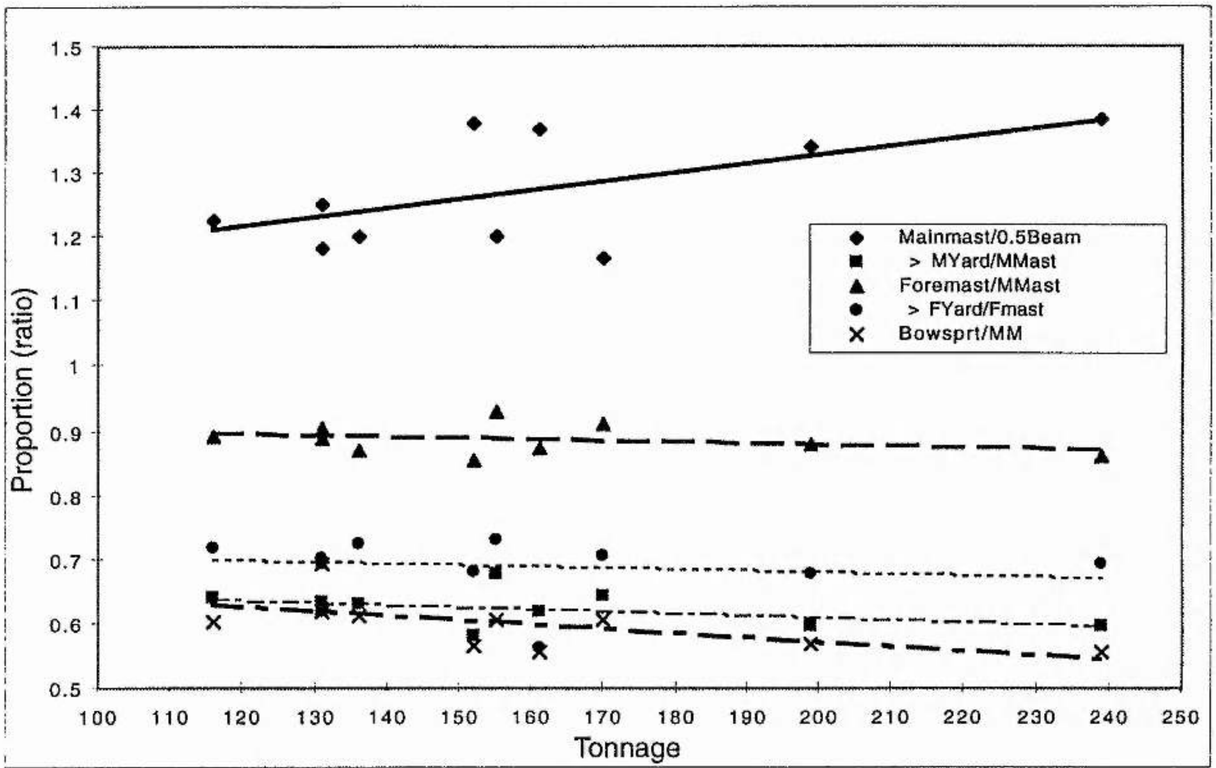


Figure E.2. Masting proportions for ten brigs masted by the Smales Firm of Whitby, 1767-1806.

The above graph indicates that the Smailes firm followed a relatively standardized set of rules for the masting of brigs. The proportions tended to decrease slightly with increasing vessel size (tonnage), except for the ratio of the mainmast to beam, which increased with increasing vessel size, at least based upon this small sample.

The two Smales ships tabulated on the next page, but not graphed, follow a similar pattern; in fact, the ratios are quite similar.

TABLE E.4
MASTING DETAILS FOR TWO SMALES SHIPS

	EMPLOYMENT	MARLBORO
Length	88.00	71.00
Beam	26.75	23.50
Tonnage-given		223
Tonnage-BOM	274	167
L/B Ratio	3.29	3.02
Date Built	1750	1761
Mainmast	68.00	59.00
Main Yard	46.00	39.50
Main Topmast	40.00	34.50
MTM Yard	36.00	32.00
Main T'gallnt	21.00	17.50
MTG Yard	26.00	21.00
Foremast	64.00	54.00
Fore Yard	41.00	36.00
Fore Topmast	36.00	31.50
FT Yard	33.00	29.00
Fore T'gallnt	19.00	16.00
FTG Yard	24.00	19.00
Mizen Mast	60.00	49.00
Miz Yard	42.00	
Miz Topmast	28.00	22.00
MT Yard	28.00	23.00
Crojack Yd	36.00	30.00
Miz Gaff		
Bowsprit	45.00	36.00
BS Yard	36.00	32.00
Jib Boom	35.00	
Jboom Yard	35.00	
RATIOS		
> Mnmast/Beam	2.54	2.51
MYard/MMast	0.68	0.67
MTM/MM	0.59	0.58
MTMYd/MTM	0.90	0.93
MTGM/MTM	0.53	0.51
MTGMYd/MTGM	1.24	1.20
> Foremast/MMast	0.94	0.92
FYard/Fmast	0.64	0.67
> Mizenmast/MM	0.88	0.83
MzYd/MzMast	0.70	0.00

TABLE E.5
A COMPARISON OF THE RIGS OF BRIGS FROM VARIOUS SOURCES

	BRIGS FROM VARIOUS SOURCES					SMALES
	Steel's Brig	Steel's Brig	Has-Bashaw	D.Mnchstr	Bilander	Averages
Length						68.97
Beam						23.13
Tonnage-given	150	200			160	170
Tonnage-BOM						159
L/B Ratio						2.98
Date Built	1794	1794	1794	1777	1775	1782.6
Mainmast	60.00	56.00	73.00	61.33	63.25	58.85
Main Yard	38.00	42.00	42.00	0.00	41.75	36.60
Main Topmast	30.00	31.00	33.00	25.83	30.50	29.70
MT Yard	30.00	31.50	33.00	26.40	30.17	28.60
Main T'gallnt	16.50	23.50	27.00	12.90	19.67	16.00
MTG Yard	21.00	23.50	22.00	13.25	19.90	20.89
Main T'gal Royal	0.00	0.00	0.00	0.00	0.00	
MTGR Yard	0.00	15.75	17.00	0.00	16.40	
Main Boom	34.00	45.00	**12	38.33	39.10	39.70
Main Gaff	18.50	28.00	30.00	20.00	27.67	22.56
Foremast	54.00	49.00	56.67	57.67	54.50	52.10
Fore Yard	36.00	42.00	48.00	33.60	40.33	35.80
Fore Topmast	32.00	31.00	36.00	30.67	32.40	30.30
FT Yard	30.00	31.50	36.00	29.40	31.40	28.60
Fore T'gallnt	16.00	23.50	29.00	15.33	20.50	15.30
FTG Yard	21.00	23.50	25.00	16.90	21.25	17.70
Fore T'gal Royal	0.00	0.00	0.00	0.00	0.00	
FTGR Yard	0.00	15.00	20.00	0.00	17.50	
Bowsprit	32.00	34.00	** 27	28.67	31.75	35.00
BS Yard	30.50	31.50	0.00	29.40	30.33	31.33
Jib Boom	26.58	24.00	29.00	22.50	26.00	21.40
RATIOS						
> Mnmast/Beam	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	2.54
MYard/MMast	0.63	0.75	0.58	0.00	0.66	0.62
MTM/MM	0.50	0.55	0.45	0.42	0.48	0.51
MTMYd/MTM	1.00	1.02	1.00	1.02	0.99	0.96
MTGM/MTM	0.55	0.76	0.82	0.50	0.64	0.54
MTGMYd/MTGM	1.27	1.00	0.81	1.03	1.01	1.20
> Foremast/MMast	0.90	0.88	0.78	0.94	0.86	0.89
FYard/Fmast	0.67	0.86	0.85	0.58	0.74	0.69
>Bowsprt/MM	0.53	0.61	#VALUE!	0.47	0.50	0.60

APPENDIX F

Merchant Vessel Stability and Sailing Qualities

The vast collection of Admiralty records at the Public Record Office, Kew, London, comprise virtually the only source of information on the performance of eighteenth-century merchant vessels. ADM 95 consists of volumes of large, printed forms on which have been entered data on the sailing qualities of naval vessels. A small percentage of these reports preserve sailing information on transports and storeships. Each form is headed:

"Observations of the Qualities of His Majesty's Ship the ___________"

Several transport reports have been extracted and summaries are presented on the following pages.

Observations on the Sailing Qualities of Vessels from the 1740s:

Lenox, Transport, March 25, 1743
(PRO, ADM 95/27:f.12)
Draft: ?
Topgallant gale: ship could make 4 knots in a "if a fresh of Wind & Smooth Water."
Reported that she could go 10 knots, maximum, but "she rolls vigorously in trough & lies too very loathsome"

Romney, storeship, ca. 1743
(PRO, ADM 95/27:f.33)
Draft: 16' 8" Afore
16' 10" Abaft (tested laden with 6 months provisions for sea service)
"In Sailing in Company with Others she will Weather Most Ships."
Made less leeway than most ships; before the wind runs 10-11 knots, rolls very easy in the trough.

Deptford Storeship, October 3, 1744
(PRO, ADM 95/27:f.46)
Jn° Fowler, Commander
Draft: 14' 6" Afore
15' 0" Abaft
Trim: "Carrys her Masts Upright, & her trim 7 or 8 Ins by the Stern"; "Steers, Tacks & Wears very well."
Topgallant gale: ship could make 4 knots in a "if a fresh of Wind & Smooth Water."
Reef topsails: "Four Knotts if smooth Water five"
"Gathers to Windward but very little & does not forereach"
"Her best sailing is two Points abaft the Beam, and will then go Eight Knotts, in Smooth Water, and in a head Sea four and a halfe, Carry her Helm a turn a Weather and is Subject to Yaw before the wind; Can spare Sail to none but Loaden Merchant Men."

Observations on the Sailing Qualities of Vessels from the 1770s and 1780s:

***Endeavour*, exploration ship, August 3, 1771**

(PRO, ADM 95/30:f.23)

Reported Best Sailing Draft:	13' 6" Afore 13' 10" Abaft	(Channel service)
	14' 8" Afore 15' 0" Abaft	(Foreign service, w/6 mo. provisions)

Topgallant gale: *Endeavour* was said to run about 5 knots and to steer well

Topsail gale: 6 knots

"Her best Sailing is with the Wind a point or two abaft the beam she will then run 7 or 8 Knots and carry a weather helm."

"No Sea can hurt her laying Too under a Main Sail or Mizon ballanc'd"

"She is a good Roader and Careens easy and without the least danger."

In answer to the querry about the height of her lowest gunport when fully loaded for foreign service, the answer was "Under water"

Note: Undoubtedly the most famous merchant vessel to be found in the sailing reports is His Majesty's Bark *Endeavour*. The *Endeavour*'s sailing qualities were recorded in August of 1771, apparently after Cook's return from his first voyage of discovery. The entries on the standard printed form are purported to be in the hand of James Cook, himself (Beaglehole 1955:I:636).

***Supply*, Storeship, January 21, 1784**

(PRO, ADM 95/37:f.78)

Draft: 15' 10" Afore

18' 0" Abaft (tested while loaded for service)

Topgallant gale: 7 knots and carries a weather helm

Topsail gale: 4 knots, behaves well

"Stays & Wears very well"

Ship sailed best with the wind 2 points off the beam, where it made 8 knots and "rolls deep but very easy."

Supply was found to be "a very weatherly Ship, nothing gets to windward of her."

Observations on the Sailing Qualities of Vessels from the 1770s and 1780s (cont.):

***Clinton,* Transport, April 6, 1784**

(PRO, ADM 95/37:f.23)

Draft: 15' 3" Afore
16' 0" Abaft

Topgallant gale: 6 knots

Topsail gale: $6^1/_2$ - 7 knots

Maimum: 11-12 knots, "Rolls very much"

"Not very Weatherly but forereaches very fast."

Under its main "She lays too very bad."

"In little winds She Sails middling well—and in fresh Gales & off the Wind She Sails exceedingly well — By the Wind & a head Sea She Sails but indifferently & holds but a very poor Wind — She carries her helm in Mid Ships."

APPENDIX G

Merchant Vessel Contracts and Surveys

Contents

A 1785 Contract for a Ship
of Approximately 330 Tons Burthen

A 1774 Contract for the Building of a Ship
of Approximately 260 Tons Burthen

A 1775 Contract for the Building of a Ship
of Approximately 240 Tons Burthen

A 1761 Contract for the Building of Two Sloops,
Each of Approximately 100 Tons Burthen

Exhibit G.1. A 1785 Contract for a Ship of Approximately 330 Tons

Source: William Rotch's Acct. Book, London & New Bedford, 1785
(The Henry Francis Du Pont Winterthur Museum)

Dimensions of a Ship sent T Rodman & G Claghorn?
80 feet keel after deduct of 3/5 of the beam for the rake for'd.
28 feet Beam
12 feet 6 inches hold
5-6-if the Cabbin is upon the upper deck
5-6 if —on the lower deck —
Wales 1 foot above the upper deck if the Cabbin is on lower deck
2 1/2 — if on the upper deck — also some timbers to
run up through the plank Shares?, for a Rail to help
fashion out? the work that the qtr. deck may not
look to high — (I mean proper qtr. deck not a poop)
if the Cabbin is above the upper deck, the qtr. deck
to be 36 feet long so at the transom the bulk head? a few feet
Flush upper deck —
Outboard plank & deck, 3 inches —
Transom not so long in proportion as the Hope
? so as to draw 2 feet more aft than forward loaded
4 wales; Stern post to run above the qtr. deck
a rise forward of 1 foot or 15 inches as need requiring
a rise aft of same height to run to the fore part of the
main ?
another rise aft of same hight to run a little for'd.
of the qtr. deck —
not so high as the Hope, but to rise a little forward
like the Maria? & Eliza? but not quite so crooked? —
a good Round bodied vessel, like the [name?] —

[*written along the side of the sheet:*]

Floor timbers to be let down on the Keel & a water course below
trunnel holes all to be board & stand some time before drove
Copper bolts of Nantucket to be used in the splices of the keel

Exhibit G.2
Contract for the Building of a Ship of Approximately 260 Tons Burthen in 1774

Source: Lopez Papers: Box 52, folder 4, folios 52-181:25-26.
(The Henry Francis Du Pont Winterthur Museum)

Articles of Agreement entered into in Newport this twenty-eighth Day of December 1774 between Sylvester Child Esq.[r] of Warren of the one part and Aaron Lopez of Newport Merchant on the part and Behalf fo Benjamin Wright & Jeremiah Meylor [?] both of Savanna [?] LaMarr in the island of Jamaica of the Other part as follows

Said Child engages to build for said Lopez on the part & behalf aforesaid a good Sustantial double deck'd Ship of the dementions following and in manner hereafter expressed Viz—
Seventy-two feet Keel, twenty-six feet beam, twelve & ahalf foot Lower hold and four foot Six Inches between decks. The whole of her timber to be good white Oak, her decks to be flush fore & aft. The Tiller to play close under beams of second deck, her plank to be all of three Inches thick, Except that of lower decks, them not less than two Inches & ahalf and of a good length. her gunnells to be of Locust Wood and her Iron to be the best from Philadelphia, to have a knee fixed under her Bowsprit instead of a head, her formast not to be placed so farr forward as is Customary, her mizinmast to be fixed much farther aft (in Proportion) than the ship Ninoys [?] but the Rake in the Stern to be on the same plan, to have a fair Round side and by no means to have a quick shear abaft, With a strait shear. The plank for her waist to be extreamly well Seasoned not less than Six Inches & ahalf in breadth or more, the Seams in the Ship to be as small as possible, her Gunwales ^or Waist^ above the second Deck to be Eighteen Inches deep, her floor timbers to be full fifteen feet long and Sixteen Inches dead Rising, Said Child also engages to do all the Iron work for the Hull of said Ship and to deliver her afloat at Warren aforesaid Completely finished to a Cleat, in a workman like manner on or before the middle of August next ensuing the date hereof together with a good Sett of Masts spars &[tc] suitable for such a ship.

In Consideration whereof the said Lopez in part and behalf aforesaid agree to allow said Child Thirteen dollars per ton for said ship; Two pence half penny Lawfull Money per pound [?] for the

[continued]

Exhibit G.2 (continued)

Iron Work of her Hull also the difference between the price of Locust & Oak Trunnells. They also agree to furnish the Iron, Pitch, Tarr, Turpentine, and Oacum necessary for said Ship as said Child may acquire them at their Own Cost, and to make payment for the whole amount of said Ship & Iron Work in the manner following Viz— One third part the amount of said ship in Cash. One third part in good Merchandise, Jamaica Rum at three Shillings & six pence Lawfull Money per Gallon and Brown Sugars at fifty Shillings Lawfull Money per Cask and the other third in English European Goods at the folowing rates Viz— Common piece Goods at Eighty per cent advance or One Hundred & Eighty Pounds Lawfull Money for One hundred pounds Sterling. The advance and Some Other Goods which it is customery to put at the same advance as hardware [?] which are to be at One hundred per cent advance, Crockery Ware at One hundred twenty percent advance & some other goods the Prices of which it is Customery to be fixed in Lawfull Money and are to be as they have been heretofore charged by said Lopez to said Child.

For the full performance of all the forgoing Articles, the Parties Hereby bind themselves & their heirs each to the Other in the Finall Sum of five hundred pounds Lawfull Money and have Interchangeably set their hands hereto the day & year above Written.

It is further agreed by the parties that in case the Non Importation Agreement now inforce and entered into by the Colonies should prevent Importing Goods from Great Brittain, that then in such Case the One third part which is payable in the above Articles in English Goods Shall be paid in Rum & Sugars at the same price as above mentioned

Witness

Samuel Lopez
Daniel Lopez

Sylvester Child
Aaron Lopez
for & in behalf of Benj. Wright &
Jerem[a] Meylor

Exhibit G.3
Contract for the Building of a Ship
of Approximately 240 Tons Burthen in 1775

Source: Lopez Papers: Box 52, folder 4, folios 52-182:27-28.
(The Henry Francis Du Pont Winterthur Museum)

Articles of agreement enter'd into in Newport Rhode Island this ninth
Day of February One thousand Seven hundred and seventy-five, Between
Nathan Miller Esquire of Warren of the One part, and Aaron Lopez, Archimides
George both of Newport Merchants, & Francis Ketch of Bedford in the province of
the Massachusetts Bay Merchant of the Other part, as follows, The said Miller
Engages to build for the said Lopez and the others concerned aforesaid, a good Substantive
Double decked Ship of the Dimentions and in manner hereafter Expressed Viz—
Seventy five foot keel, strait Rabbit, twenty four foot & a half Beam, twelve
foot hold and five foot and ahalf between decks, The whole of her timbers to be
good white Oak, her Decks to run flush fore and aft, the Tiller to play close under
the Beams of the Second Deck, her plank about her Bottom & lower deck to be all
Laid full two inch and a half thick of good length excepting three Streaks at
the floor Timber heads two streaks under the bends & one at top the Wales all
which are to be full three Inches thick, as also those of the upper Decks—
Her trunnels to be of Locust wood, her foremast not to be placed so farr
forward as it is Customery— her mainmast to be fixed farther aft in
proportion— her Rake in the stern to be on the same plane as the Ship Nancy [?]
to have a fair Round Side and by no means to have a quick Shear abaft
The plank of her waist to be extreamly well seasoned, and not less than Six
Inches and a half in breadth— The Seams to be as small as possible— her Gun-
Wales or waist to be Eighteen Inches deep— said Miller also engages to do all
the Iron work for the hull of said Ship at the rate of two pence half penny
Lawfull Money per pound [?] for the work and to deliver her afloat at Warren
aforesaid Compleatly finished to aCleat in a workman like manner on or
before the Middle of May next Ensuing the date hereof, together with a good sett
of masts, spars &c suitable for such a Ship, In Consideration
whereof the said Lopez and concerned agrees to allow said Miller twelve dollars &
a half per Ton for said ship, also the difference between the price of Locust &
Oak trunnels, they also agree to furnish the Iron, Pitch, Tarr, Turpentine
and oacum Necessary for said ship and to make payment for
the whole amount of said Ship and Iron work in manner following Viz— ...

[Note: the remainder of the contract, concerning payment, has not been included.]

Exhibit G.4
Contract for the Building of Two Sloops,
Each of Approximately 100 Tons Burthen in 1761

Source: Lopez Papers: Box 52, folder 4, folios 52-189 (2 pp.).
(The Henry Francis Du Pont Winterthur Museum)

Articles of Agreement made & Concluded upon this fifth
Day of August in the first Year of his Majestys Reign George the third King of
Great Britain Viz— Anno Domini One Thousand Seven Hundred & Sixty One
Between Aaron Lopez of Newport in the County of Newport in the Colony
of Rhode Island Merchant on the one part, And Israel Barney & Jonathan
Hill of [?illegible?] Massachusetts
Bay Merchants, on the other part.— Thereto [?] that the said Israel Barney
& Jonathan Hill for and in Consideration of the sum hereafter mentioned, doth
hereby Agree Bargain & Contract to Build or Cause to be Built for the said Aaron
Lopez, Two Good and Substaniall single decked Sloops of the following Dimensions
Viz— one of the said Sloops to be about Fifty foot in Length by the Keel, Twenty
foot in Breadth by the Beam, & Eight foot Deep in the Hold—The other
Sloop to be about Forty Eight foot in Length by the Keel, Nineteen foot in
Breadth by the Beam, & Eight foot Deep in the Hold. —— And
as the said Lopez Reposes much Confidence in the Integrity of said Barney & Hill, &
of their Knowledge in Ship Building, He does not descend to any further particulars
Respecting said Vessells, but in Generall the said Barney & Hill obliges themselves
their Heirs & Assigns, to Build said Vessells of Suitable Materials of every kind, and
of proper Sizes & forms, Suitable to the above Dimensions, And to do every thing
(or Cause to be done) what is Customery for Ship Carpenters to do for such Vessells
and anything further that the said Lopez shall request them to do [illegible]
Lopez Consenting to pay him for the same, And they to have the Whole [?] of the
Work performed in a Faithfull and Workmanlike manner. And to Comp[lete]
the same and Deliver said Vessells Water Born to said Lopez on or before the Ten[th]
Day of March next ensuing from this Date— And the Said Aaron Lopez
doth Hereby Bind & Oblige himself, his Heirs, and Assigns, to pay to the said Barney
& Hill their Heirs & Assigns, The Amount of Sixty Seven pounds Ten Shillings Rhode Island Old
Tenor for every Ton ....

Sign'd Seal'd & deliver'd (after raising the severall
Errors herein contained) in presence of Barney & Hill

NB Said Lopez obliges himself to procure the pitch Tarr & ockum for Said Vessels & the Iron
required for the Same —

Witness -- John Marten Peter Simon Junr Aaron Lopez

APPENDIX H

Specifications for the *Betsy,* 1772

Specifications for scantlings and fastenings for the 176-ton collier brig *Betsy* are presented in the following table. *Betsy* has the following main dimensions:

Length between perpendiculars =	73' $1^5/_8$"
Maximum beam, to the outside of the planking =	23' 7 $^1/_4$ "
Tonnage, burthen (calculated) =	176 $^{32}/_{94}$ tons

The *Betsy*'s specifications are compared in this table to those of the brig *Weazel,* of 201 tons, as described in *A Shipbuilder's Repository* (Anon. 1788)

Scantlings & Specifications	*Betsy* ft.	*Betsy* in.	*Weazel* ft.	*Weazel* in.
Specs from Old Time Ships (From Sbldr's Repository)				
Specs given for Weazel, 201 tons				
Length:				
By the keel for tonnage	58	11 $^5/_8$	60	8
From the fore part of the stem, at the height of the hawse holes, to the aft part of the stern post, at the height of the wing transom	73	1 $^5/_8$	80	5
From the foremost perpendicular to the center of the dead flat	33	11	34	5
Of the tread of the keel, from the aft side of the post to the foremost part of the fore foot	67	0	66	1
Breadth:				
Extreme, allowing only the thickness of the bottom on each side to be added to the breadth moulded, to compute it	23	7 $^1/_4$	25	0
Moulded	23	1 $^3/_4$	24	7
Height:				
Of the lower deck from the upper edge of the keel to the upper side of the plank, at the middle line of the deck				
At the foremost perpendicular	12	10	13	6
At after perpendicular	13	2	16	1
Depth:				
In the hold (taken from the strake next to the limber boards)	8	6	11	0
Draught of Water: Afore	9	6	9	0
Abaft	9	6	11	6
Burthen in tons	176 $^{32}/_{94}$		201	

Scantlings & Specifications	*Betsy*		*Weazel*	
	ft.	in.	ft.	in.
Lower Deck:				
Beams to round	0	9 3/4	0	6 1/2
Plank thick	0	1 1/2?	0	3
Stern post:				
Square at the head	1	1	1	1
Fore and aft at the keel (the false post included)			2	1
Rake of the post	*11 deg.*		---	
Stem:				
The stem to be moulded	1	4 3/4	1	6
Number of pieces	2		2	
Apron:				
The false stem or apron to be thick	---		0	8
And in breadth			1	1
Apron chocks:	*0*	*9 5/8*	---	
Main keel:				
Square in the midships	1	2 3/8	1	0
False keel:				
The false keel to be thick	none		0	5
Number of pieces			4	
Keelson:				
The keelson, sided	1	2 3/8	0	11 1/2
molded. midships	1	10	0	11 1/2
Scored down on the floor timbers	0			0 1/2
Number of pieces	?		4	
Room and space:				
The room and space of the timbers is	2	4 1/4	2	0
Number of rooms in the after body	17 ?		20	
Ditto in the fore body	8 ?		16	
Floors:				
The floor timbers in the bearing of the ship. Sided (avg)	1	2	0	10
To be moulded at heads (avg)	0	10	0	8
Lower futtocks:				
Sided in midships	1	0	0	9 1/2
Moulded at the heads	0	9	0	7
Bottom:				
The plank of the bottom thick	0	2 3/4	0	2 1/2
Main wales:				
The main wales in breadth from upper to lower edge	1	10 3/4	1	6
And in thickness	0	5	0	4

APPENDIX I

Measured and Computed Attributes for Chapman's Merchant Vessels

Contents

Chapman Frigates, Barks and Cats

Chapman Pinks, Hagboats and Shallow-Draught Vessels

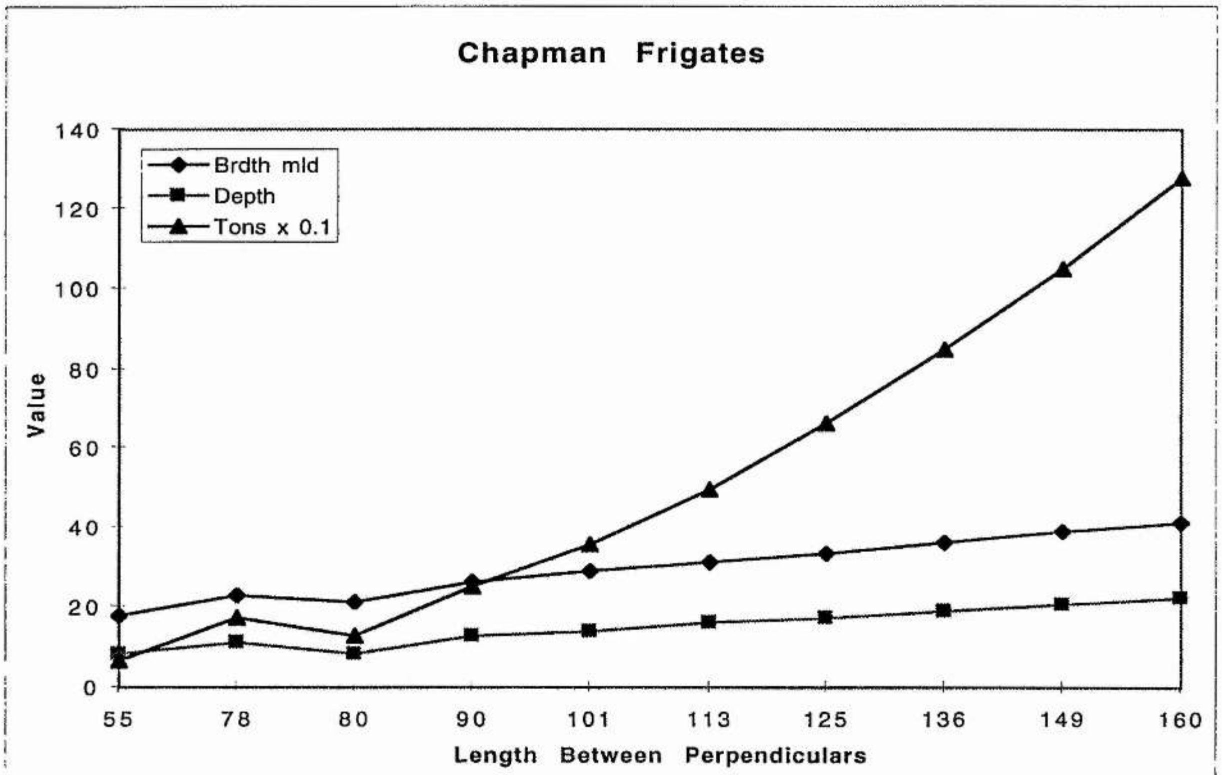
Breadth, Depth and Tonnage vs. Length
(All Five Chapman Classes Combined)

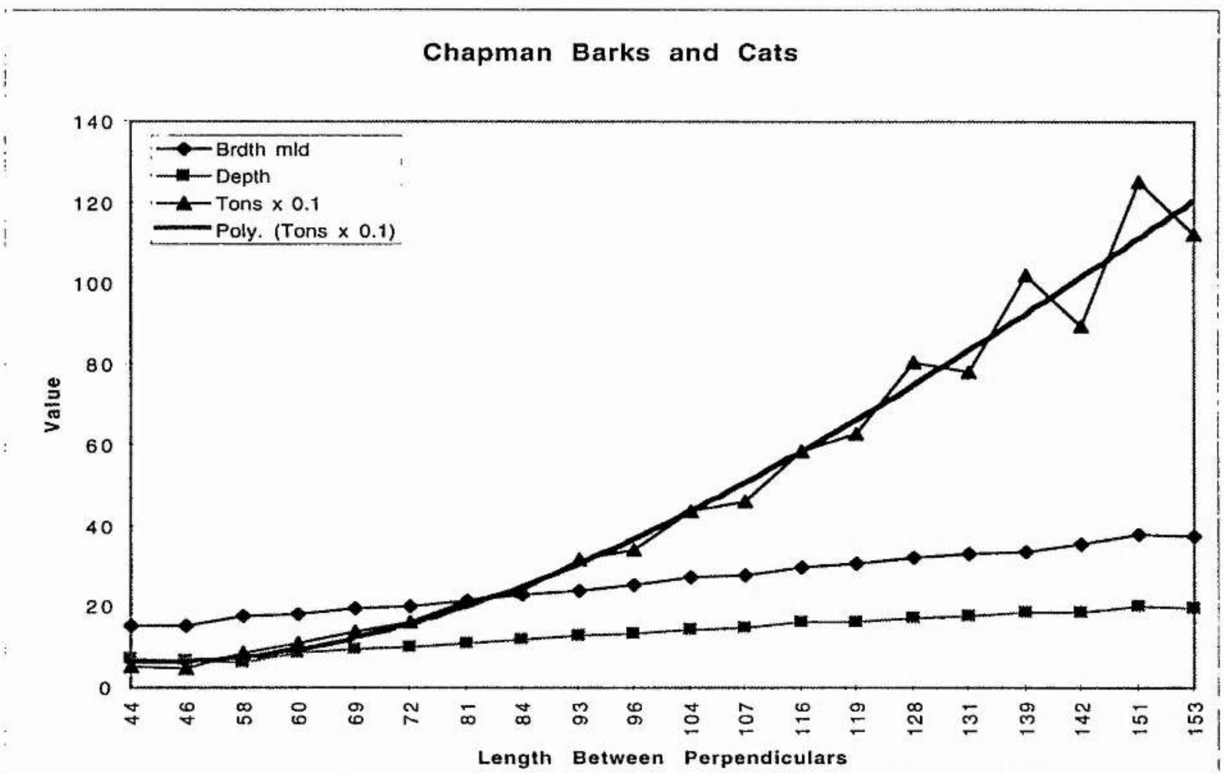
Chapman Frigates, Barks and Cats compared
(In Swedish Units)

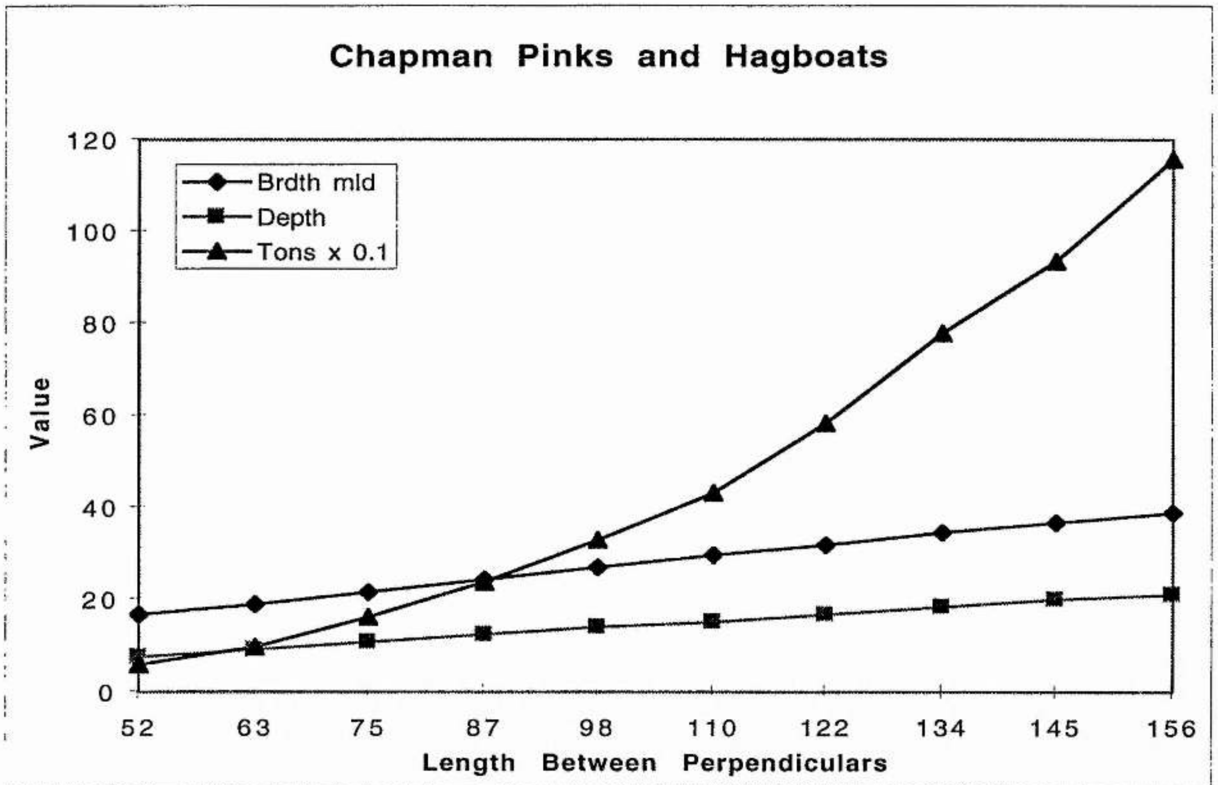
Measured and Computed Attributes for Chapman's Merchant Vessels

It will be seen from the following graphs that the vessels illustrated by F. H. af Chapman in his Architectural Navalis Mercatoria (1768) were based on theoretical proportions, mostly based on parabolic curves. The graphs also make clear that the basic dimensions and ratios are very consistent, even among different classes of vessels.

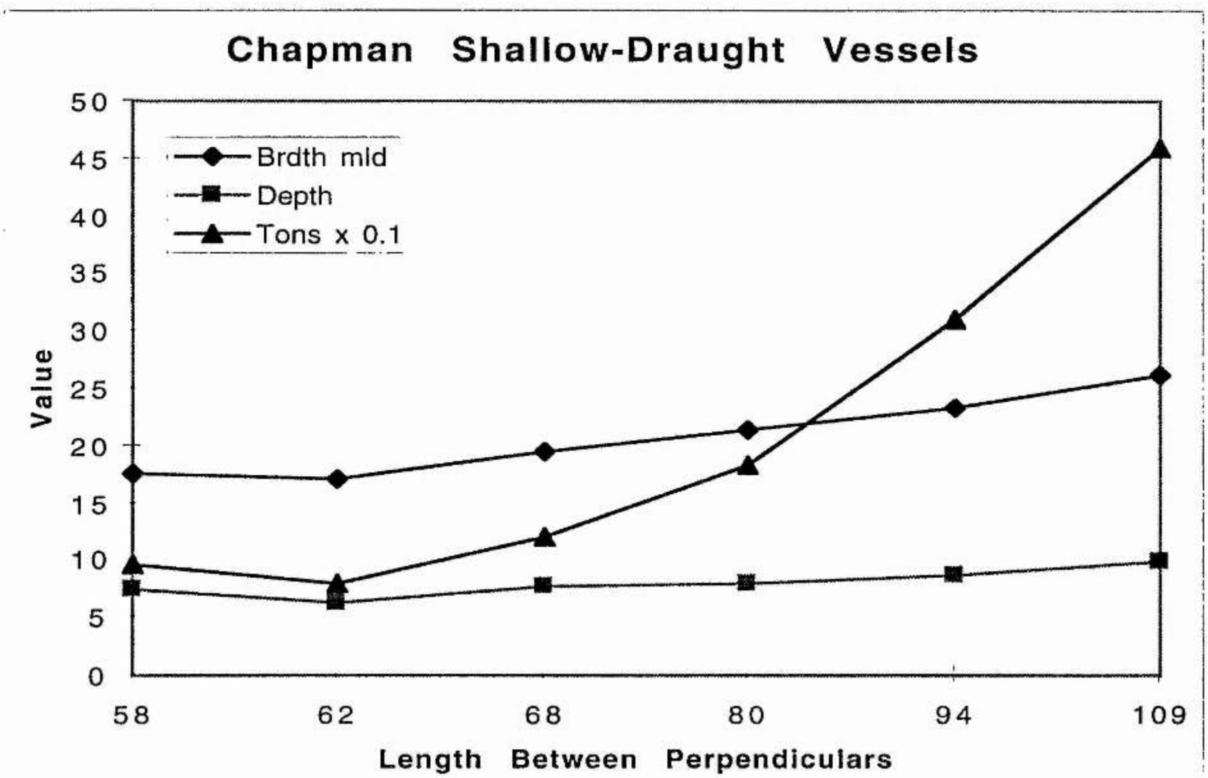
There can be no doubt that Chapman's draughts almost all represent theoretical, rather than actual, vessels. This fact becomes abundantly clear when Chapman's data are compared with those from actual vessels, as seen in Appendices C - E.


Chapman Frigates
Brdth mld
Depth
Tons x 0.1
Value
140
120
100
80
60
40
20
0
55 78 80 90 101 113 125 136 149 160
Length Between Perpendiculars

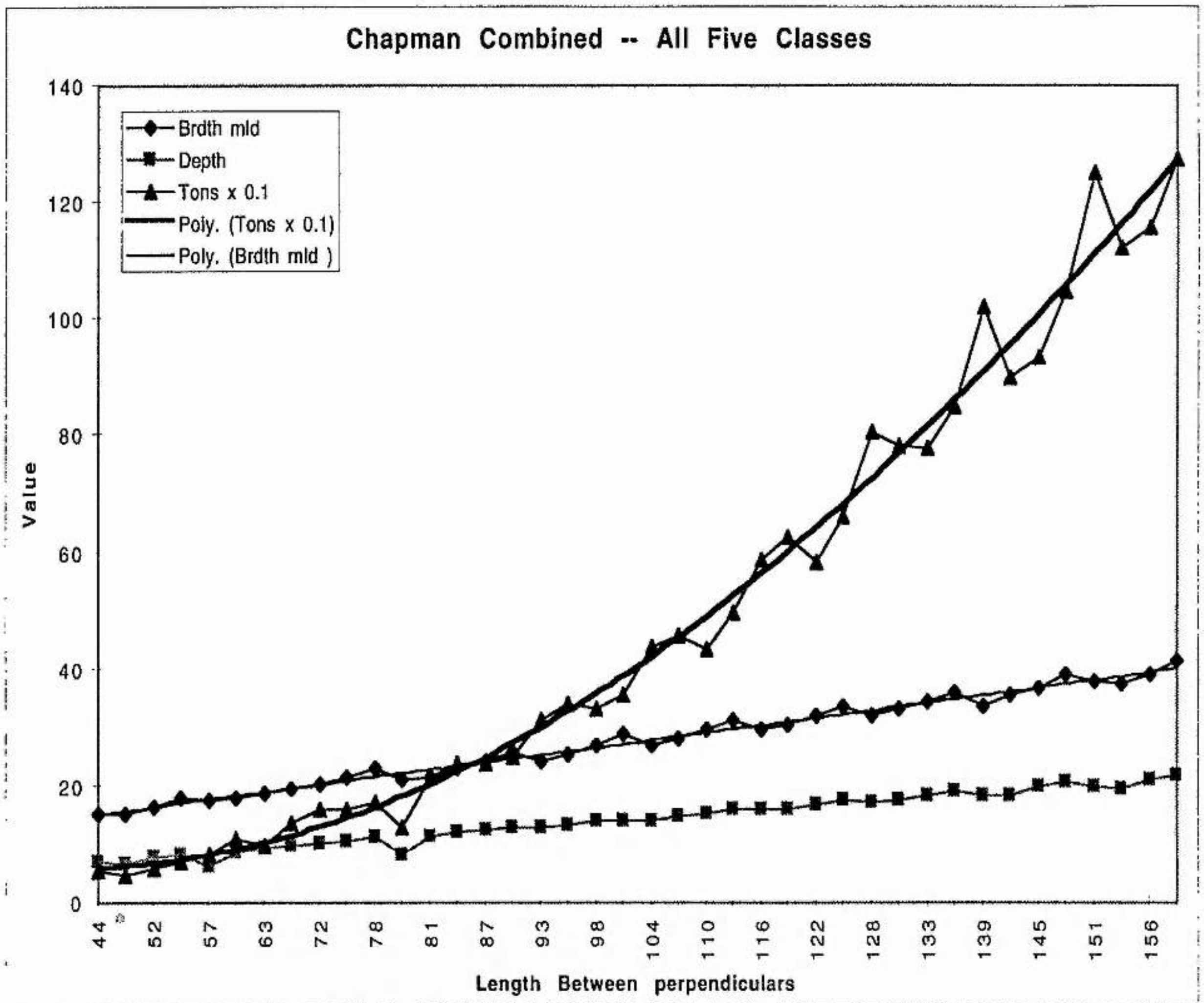

Chapman Barks and Cats
Brdth mld
Depth
Tons x 0.1
Poly. (Tons x 0.1)
Value
140
120
100
80
60
40
20
0
44 46 58 60 69 72 81 84 93 96 104 107 116 119 128 131 139 142 151 153
Length Between Perpendiculars



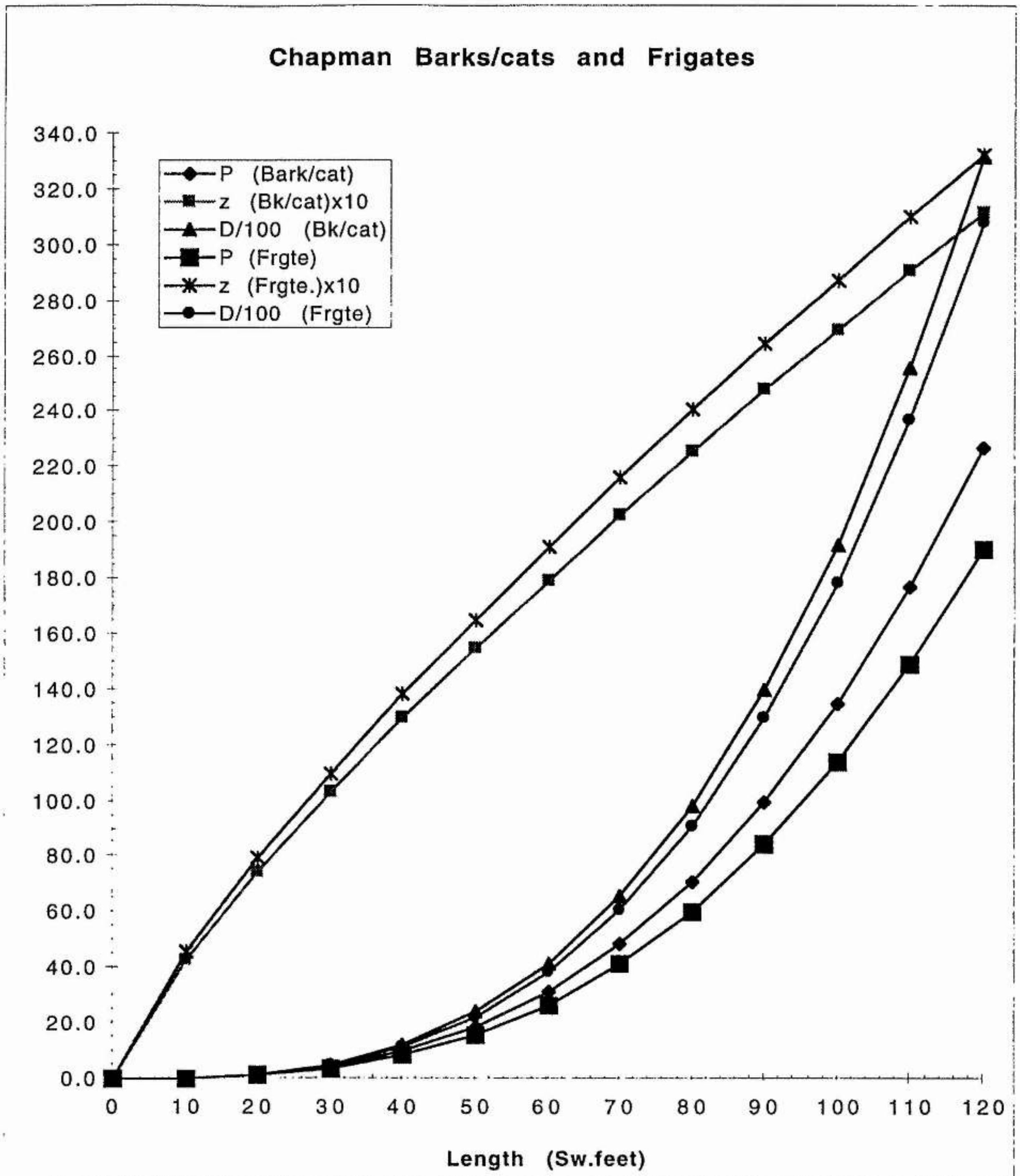
Chapman Pinks and Hagboats
Brdth mld
Depth
Tons x 0.1
Value
0
20
40
60
80
100
120
52
63
75
87
98
110
122
134
145
156
Length Between Perpendiculars



Chapman Shallow-Draught Vessels
Brdth mld
Depth
Tons x 0.1
Value
0
5
10
15
20
25
30
35
40
45
50
58
62
68
80
94
109
Length Between Perpendiculars

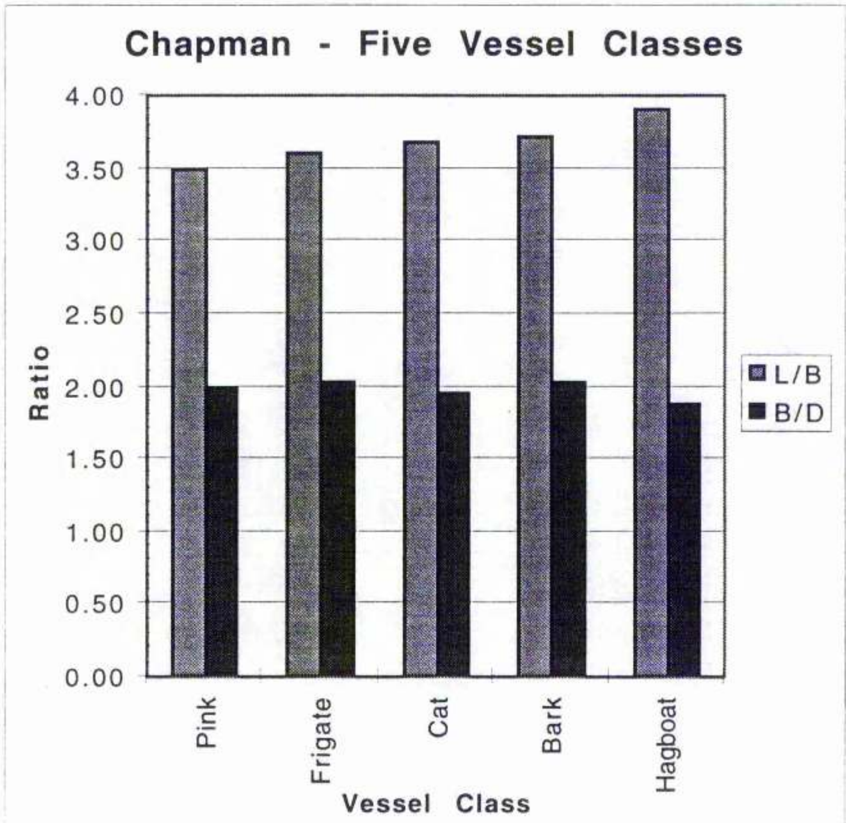


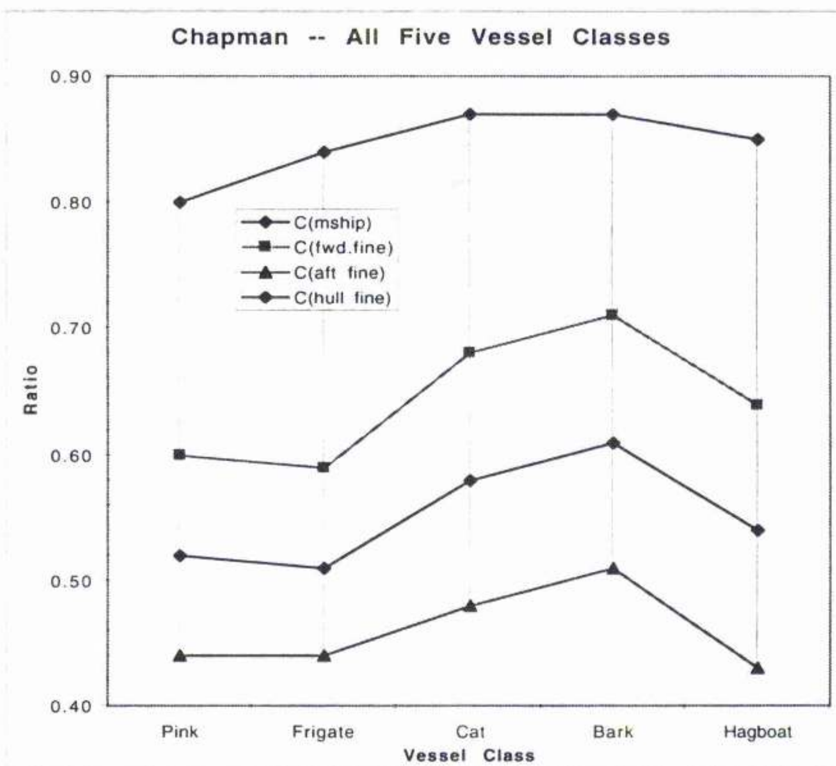
In the above graph, all five vessel classes are sorted by length and plotted togeher. It can be seen that the resulting curves are relatively smooth and regular.



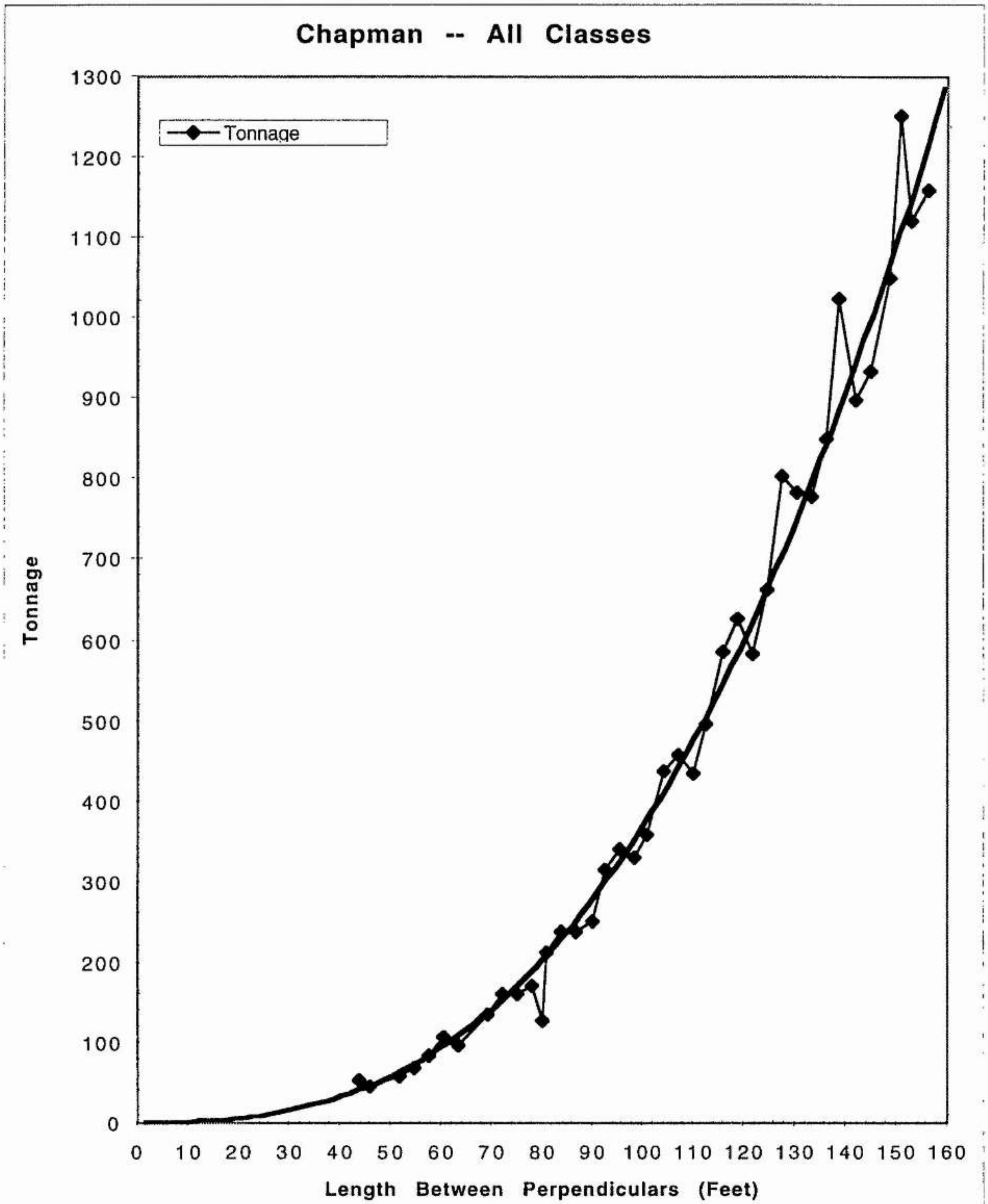
Chapman Barks/cats and Frigates
340.0
320.0
300.0
280.0
260.0
240.0
220.0
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
P (Bark/cat)
z (Bk/cat)x10
D/100 (Bk/cat)
P (Frgte)
z (Frgte.)x10
D/100 (Frgte)
0 10 20 30 40 50 60 70 80 90 100 110 120
Length (Sw.feet)

Chapman -- Dimensionless Coefficients for All Five Vessel Classes





Chapman -- Tonnage vs. Length for All Five Vessel Classes



APPENDIX J

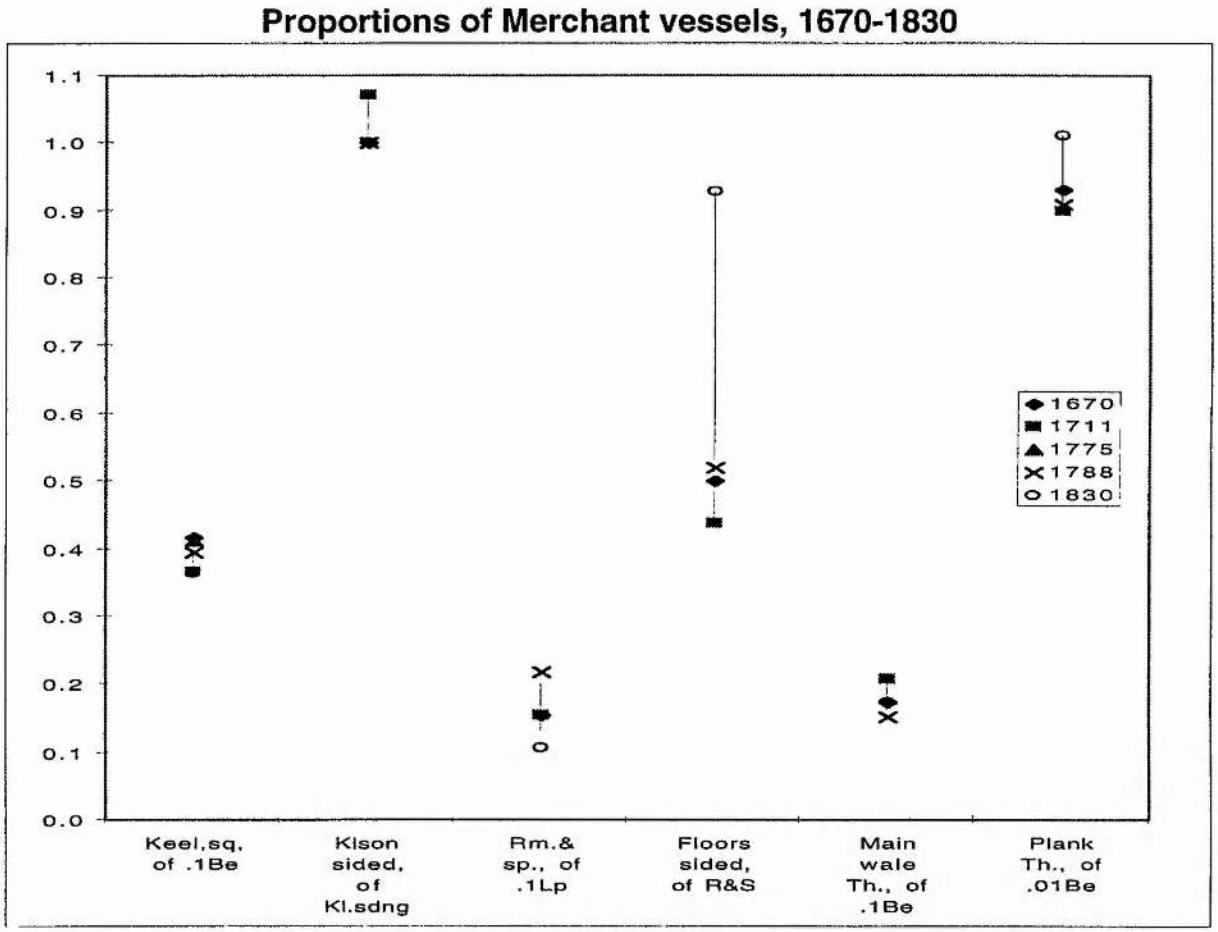
Summary for Archaeologists

Contents

Proportions of Merchant vessels, 1670-1830

Given A Length Between Perpendiculars ...
Estimate Breadth, Depth,
Length/Breadth Ratio And Breadth/Depth Ratio

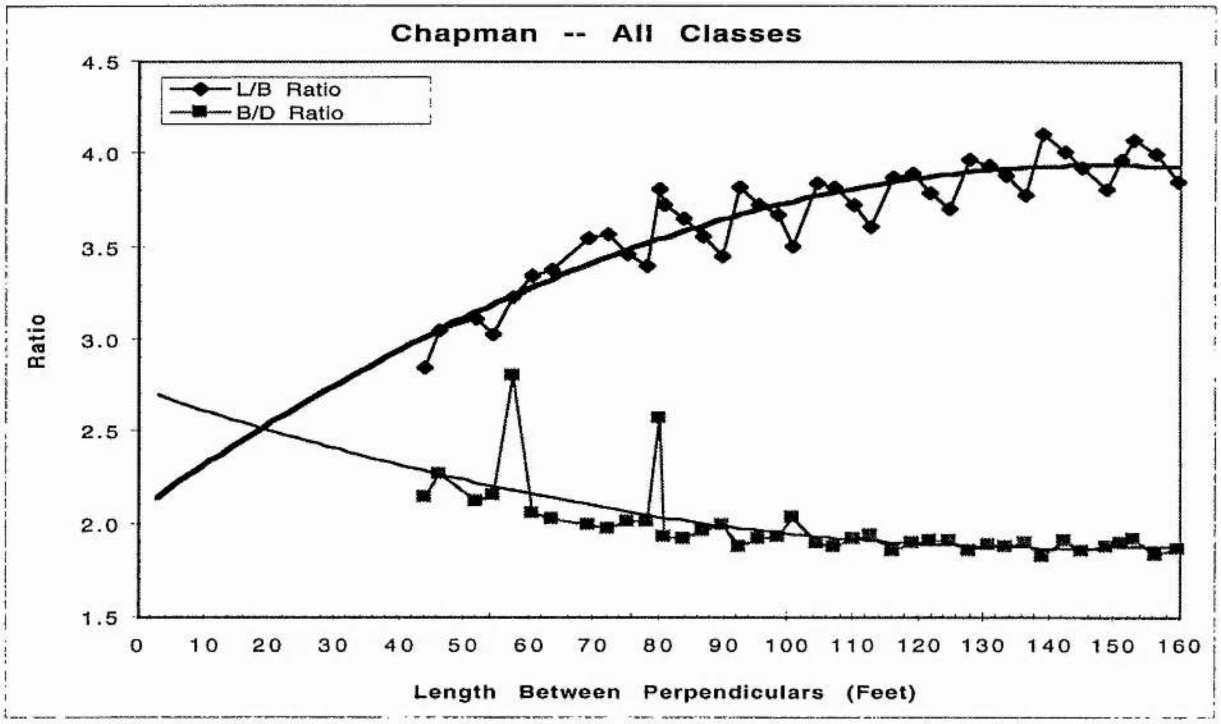
Given A Length Between Perpendiculars ...
Estimate Tonnage

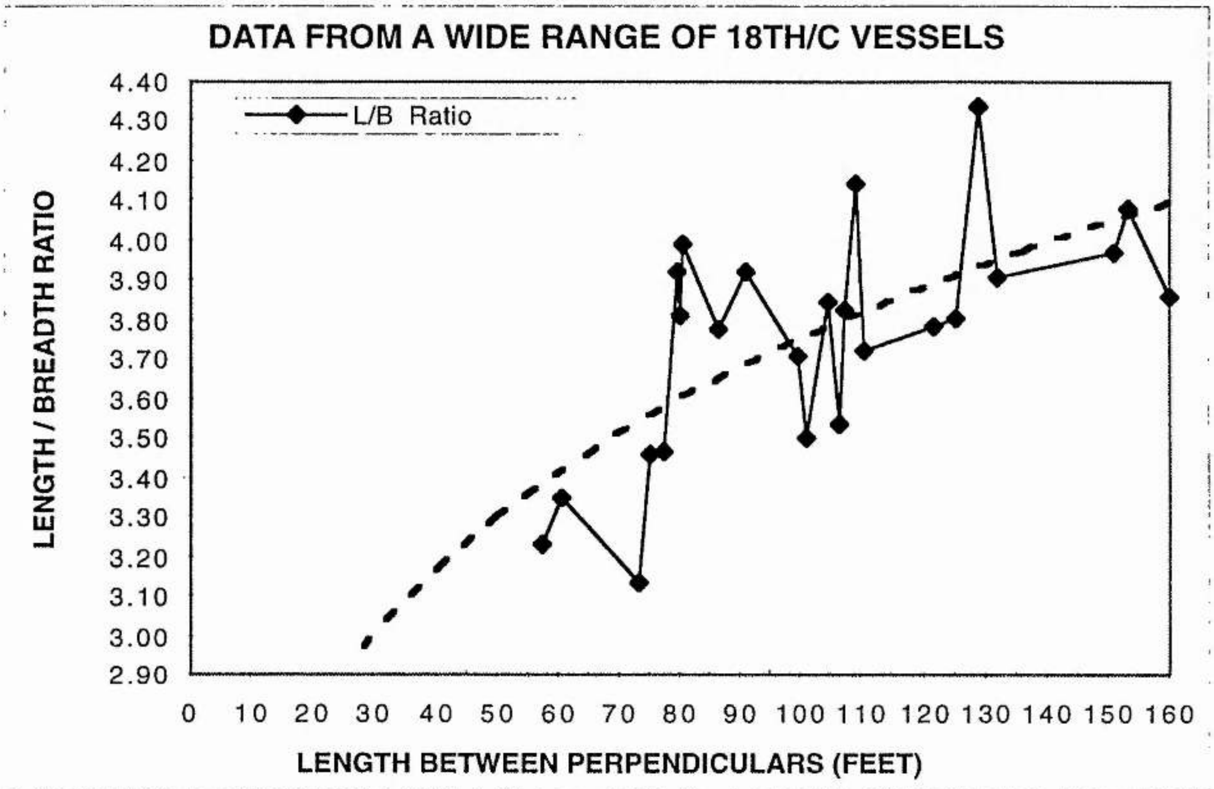


	Proportions - Calculated or Measured				
	Deane 1670	Sutherland 1711	Chapman 1775	Anon. 1788	Hedderwick 1830
Source Tonnage (normalized):	899	523	435	400	408
Extreme Breadth, Be, actual	36.0	32.0	29.42	29.57	28.79
Lengths: betw. perpendiculars (Lp)	152.0	115.7	112.2	103.8	109.7
on keel (Lk), of Lp	0.7895	0.8124	0.8985		
fwd.perp.to dead flat, of Lp	0.4092	0.3707	0.4255	0.3989	0.4333
Breadths: Extreme (Be), of Lp	0.2631	0.2766	0.2622	0.2849	0.2625
Depth in the hold, of Be:	0.5263	0.5505	0.4148	0.4364	0.7004
Draught, Load, midships, of Be	0.4750	0.4237	0.4963	0.5453	
Hull Shape:					
Rake of Sternpost, of Lp	0.0361	0.0303	0.0203		
Rake of Stempost, of Lp	0.1771	0.1659	0.0798		
Ht.toptimber line m-ships, of Be	0.6794	0.7340		0.8000	
Scantlings of timbers:					
Main keel, sq., m-ships, of Be	0.0417	0.0365	0.0411	0.0394	0.0362
Room and space, of Lp	0.0154	0.0155	—	0.0217	0.0106
Floors sided m-ships, of rm.&sp. .	0.5002	0.4372	—	0.5200	0.9286
Keelson sided, of siding of keel	1.0000	1.0714	—	1.0000	1.0000
Thickness of main wales, of Be	0.0174	0.0208	—	0.0152	0.0174
Th. of plank of bottom, of Be	0.0093	0.0090	—	0.0091	0.0101

GIVEN A LENGTH BETWEEN PERPENDICULARS ...

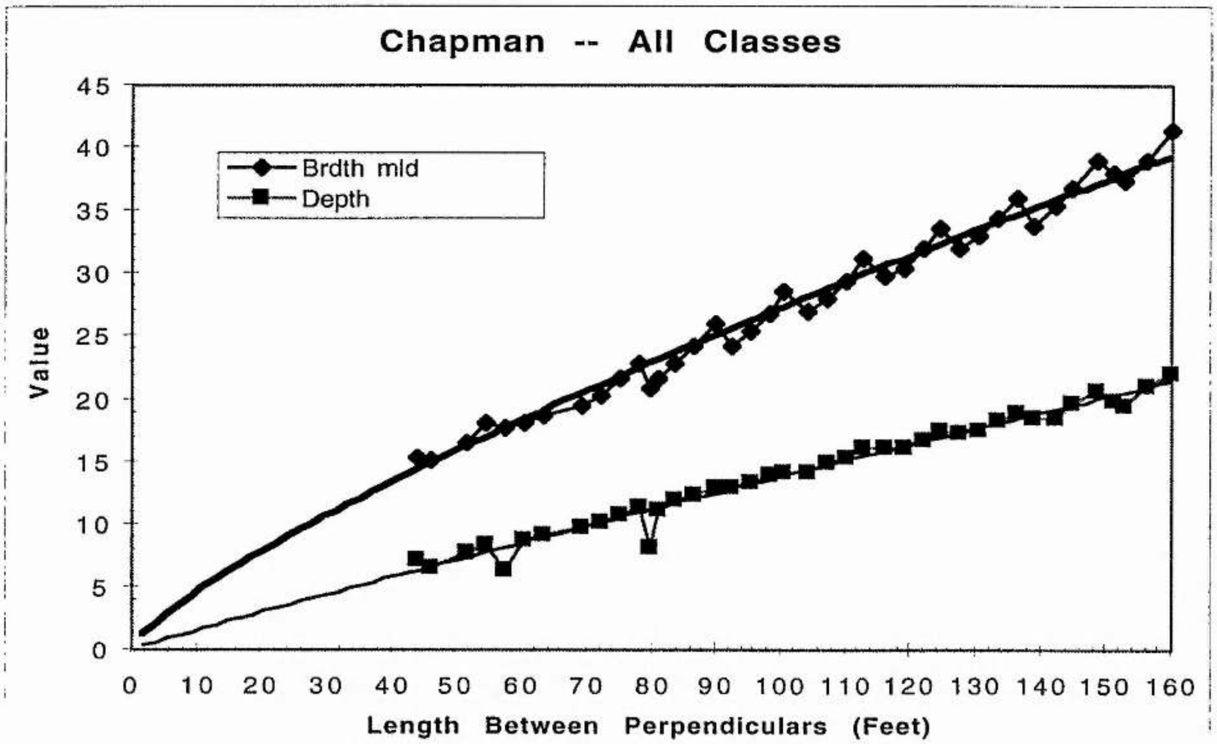
ESTIMATE LENGTH/BREADTH RATIO AND BREADTH/DEPTH RATIO

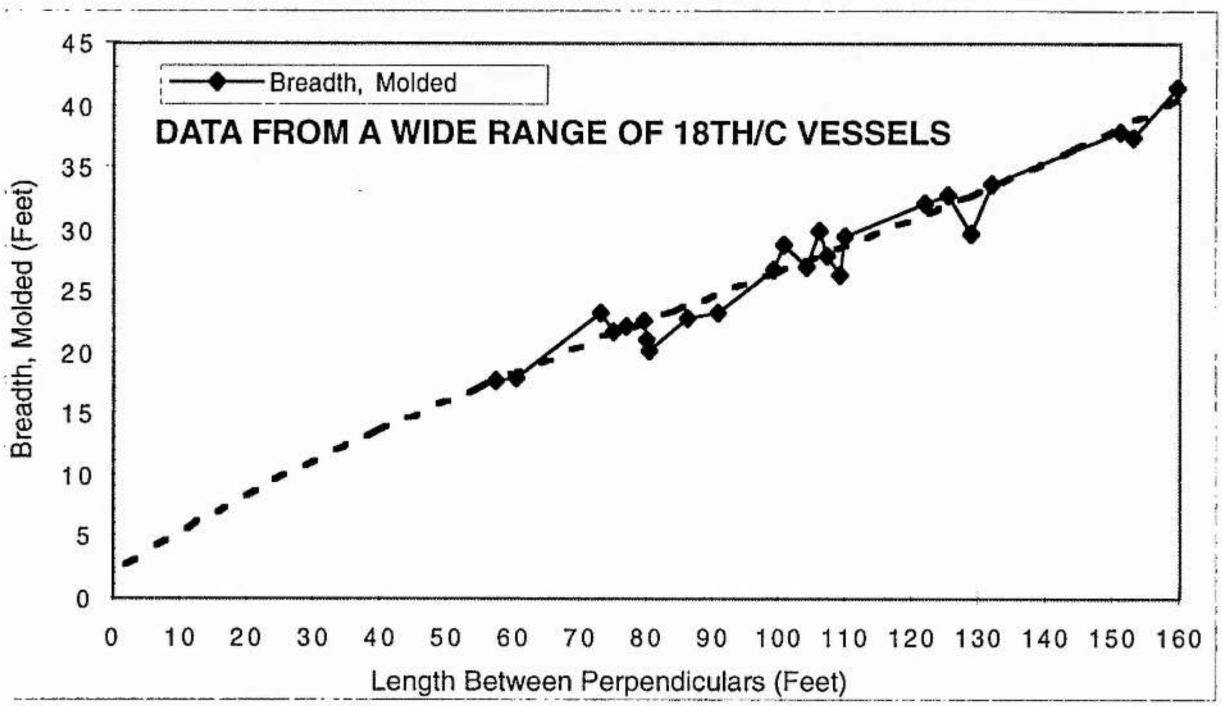




GIVEN A LENGTH BETWEEN PERPENDICULARS ...

ESTIMATE BREADTH AND DEPTH





GIVEN A LENGTH BETWEEN PERPENDICULARS ...

ESTIMATE TONNAGE

Tonnage vs. Length for a variety of Chapman and actual vessels

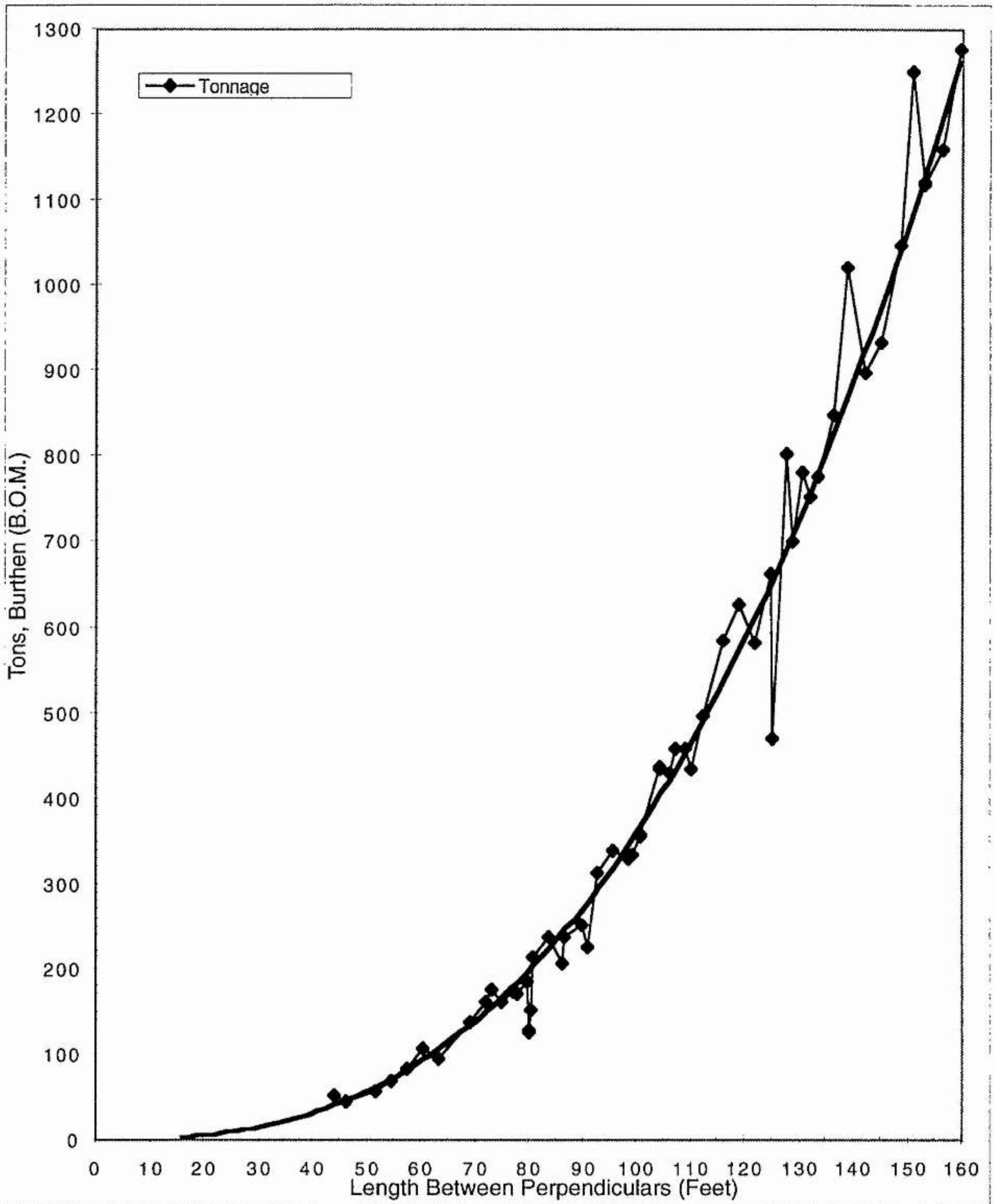


Figure E.1

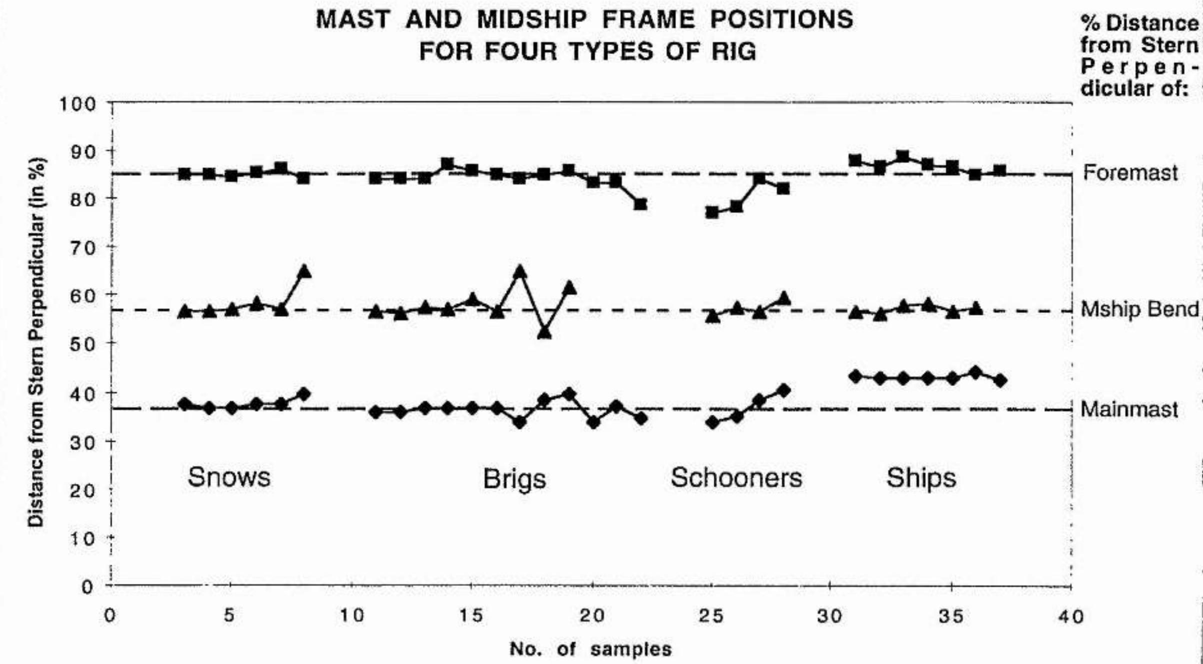


TABLE E.2
AVERAGE MAST POSITIONS FOR A VARIETY OF VESSEL TYPES

VESSEL TYPE	BURTHEN (TONS)	DIST. FROM STERN PERPENDICULAR (IN %) MAINMAST	FOREMAST	MIDSHIP BEND
SNOWS (CHAPMAN)	253.9	37.5	85.2	57.3
(MACGREGOR)	137.0	39.7	84.4	65.2
BRIGS (CHAPMAN)	154.0	36.6	85.2	57.4
(MACGREGOR)	176.3	37.4	85.1	59.9
(DAVIS)		35.5	81.9	
SCHOONERS (CHAPMAN)	154.8	34.7	77.8	56.9
(MACGREGOR)	119.0	39.6	83.2	58.2
SHIPS (CHAPMAN)	345.6	43.4	87.7	57.5
(MACGREGOR)	317.5	43.7	85.8	57.2
(DAVIS, 1-4-6)		42.9	85.7	
SHIPWRECK 44YO88	180.0	41.4	85.3	60.2?

Glossary

Apron: A curved timber that is fastened to the after surface of the stem or to the top of the forward end of the keel and the after surface of the stem; an inner stempost.

Ballast: Dense material (usually stone, iron or sand) placed in the hold of a vessel to lower its center of gravity, thus increasing its stability.

Bark (barque): In the eighteenth century, this term referred to a hull form rather than a type of rig; the bark had a full, round bow, a full stern and had no figurehead or beakhead. In the next century, bark generally referred to a three-masted vessel, square-rigged on the fore and main masts, with a fore-and-aft sail on the mizzen.

Batten: See **Ribband**

Beam: An athwartships timber that supports a deck and provides lateral strength; also a term for a vessel's width (see **Breadth**).

Bevel: The fore-and-aft angle or curvature cut into an inner or outer frame surface

Bibs: See **cheeks**.

Bilge: The curved area of a hull's bottom on which it would rest if grounded; generally at or near the floor heads.

Block: A pulley (wheel in a wooden case) through which a rope or ropes are passed to create a mechanical advantage for lifting, controling sails, etc.

Block strap: A rope or iron strap wrapped around a block to allow it to be attached to a fixed point or other block.

Boatswain: A warrant officer or senior sailor responsible for all equipment pertaining to the working of a vessel.

Boltrope: The rope sewn around the edges of a sail to give it strength and to attach support and control ropes.

Boom: A spar used for extending the foot of a fore-and-aft sail.

Bowsprit: A mast-sized spar extending forward from the stem of a vessel to permit attachment of mast stays and headsails.

Breadth: The width, or **beam**, of a vessel's hull. *Maximum breadth* is the maximum width of the hull measured to the outside of the planking, excluding thicker wales; *molded breadth* is hull width measured to the outside of the frame faces.

Breast hook: A large horizontal curved timber, or knee, fastened to the stem and forward frames to reinforce the bow.

Brig (Brigantine): Both names were applied to two-masted vessels, as was the name **snow**. In general, a brig was square-rigged on both masts, and usually carried a fore-and-aft driver sail on the mainmast, while a brigantine, at least later in the century, had no square-set sails on the mainmast.

Bulkhead: Wooden partition, transverse or longitudinal, which separates portions of a vessel into compartments.

Cable-laid rope: A heavy rope made by twisting three **hawser-laid** ropes together; a cable is a heavy cable-laid rope attached to an anchor.

Cant frame (timber): A framing timber positioned obliquely to the keel centerline in the ends of a vessel where standard frames could not be used.

Cargo: Merchandise or goods carried aboard a vessel from port to port, usually for hire or for sale.

Carvel-built (planked): A hull planked so that the seams are flush, or "butted," as differentiated from **clinker-built**.

Ceiling: The long, longitudinal wooden planks which are attached to the inside of the frames on most wooden vessels to form an inner "skin."

Chain plates: Iron chains or straps bolted to the outside of a vessel's sides to which the mast supports (shrouds) are attached by rope and deadeyes.

Cheeks: Wooden shoulders, or braces, bolted to the mast below the masthead to support the trestletrees; also referred to as **bibs**.

Chock: An angular block or wedge used to fill out areas between timbers, or to separate them.

Clamp: A thick inner wale that supports the ends of the deck beams

Clinker-built (planked): Planked so that each outer plank overlaps and is fastened to the plank immediately below it, as differentiated from **carvel-built**.

Collier: A vessel which carried coal; by the latter half of the eighteenth century the term seems to have been applied somewhat generically to the sturdy merchant vessels built in the north of England. These were flat-floored, bluff-bowed and designed to carry a large cargo of coal, although they were often employed in other carrying trades; the most famous are James Cook's **Endeavour** and Bligh's **Bounty**.

Cordage: a general term for ropes, cables, hawsers and "small stuff;" the term "line" was not used in the eighteenth century.

Counter: The hollow part of a vessel's stern; the transverse section between the bottom of the stern and the wing transom; sometimes used to refer to the entire transverse area between the top of the sternpost and the rail, or taffrail.

Cringle: A short loop of rope spliced into the **boltrope** of a sail as a means of allowing ropes to be attached.

Cross-chocks: Timber fixed across the keel or deadwood to join the heels of the first futtocks.

Crosstrees: Wooden spreaders attached to masts transversly across the trestletrees to support upper mast sections via shrouds and deadeyes.

Crutch: A curved timber placed in the stern and serving the same type of reinforcement as a **breast hook** in the bow; also, a bracing timber used to prevent a mast step from shifting laterally.

Cutwater: The forwardmost segment of the stem; the stem piece, or nosing, that first parts the water.

Deadeye: A circular wooden block with no sheave (pulley), but instead having three holes through which a lanyard, used to tighten **shrouds** and **stays** is passed.

Dead-flat: See **Midships bend.**

Deadwood: Large timbers fastened on top of the keel, usually in the ends of the lower hull, to fill out the narrow parts of a vessel's underbody.

Draught (draft): A drawing or plan, usually showing the three basic views of a vessel's hull and lines; also, the depth to which a hull is immersed.

Driver: The gaff-headed sail on the aftermost mast of a ship, bark, brig, snow or brigantine; the driver can have a lower boom or be loose-footed.

Fathom: A length used for the measurement of depth (and sometimes, length of rope); a fathom is six feet, originally, the lenth of the spread of a man's arms.

Fay: To fit or join timbers closely together.

Fid: A tapered wooden shaft used for opening strands of rope for splicing.

Filler (filling) piece [fillet]: A timber or block used to fill out or build up an area, such as to build up a frame so that it would fair with planking or ceiling, or as spacers between frames to maintain rigidity.

Fillet: See **filler piece**, above.

Floor (floor timber): A frame timber that crosses the keel and spans the bottom of the hull; the central segment of a compound frame (also, see futtock).

Frames: The timbers that give a vessel its form and strength, providing the "skeleton" upon which the planking is attached; sometimes referred to as "ribs." Transverse timbers, or assemblages of timbers, that describe a hull's body shape and to which planking, ceiling and deck supports are attached. A *compound frame* consists of a **floor timber**, the adjoining **futtocks** and *top timbers. Square frames* were set perpendicular to the keel, while *cant frames* ran obliquely to the keel.

Futtock: One of the middle timber segments of a **frame**; a frame other than a **floor timber**, *half-frame* or *top timber*.

Gaff: A spar to which the head of a fore-and-aft sail is attached.

Garboard strake: The outer plank that is fitted into the rabbet of the keel.

Gripe: A curved timber joining the forward end of the keel to the lower end of the knee of the head; generally, the same as *forefoot.*

Gudgeon: The female part of a rudder hinge; a metal bracket fastened to the sternpost into which a rudder **pintle** was hung.

Half-frames (half-timbers): Those frames near bow and stern that butt against the keel or deadwood anad do not cross the keel; normally used in pairs.

Halliard: A rope used for hoisting a sail, gaff, yard, flag, etc.

Handspike: a bar with one end squared for use in turning capstans and windlasses; in gunnery, a crowbar-like bar used for training a cannon.

Hawser: A heavy rope or light cable, generally with a circumference of five inches or more, used for anchoring, mooring, etc.

Hawser-laid rope: rope made up of three strands twisted counter-clockwise; the most common type of rope aboard a ship.

Head: A general term for the forward part of a ship; the forward end of a *keel*, the upper end of a *mast* or of a *timber*; also, a term for a shipboard latrine.

Heel: The junction of the *keel* and *sternpost*; the lower end of a *mast*.

Hold: A term that generally refers to the space within a vessel's hull where ballast, cargo and stores are placed; the interior of a vessel below the lower deck.

Hood ends: The ends of the planks that fit into the rabbets of the stem- and sternpost.

Hull: The main structure of a vessel, consisting of the planked frames and decks, but not including the masts, yards and rigging.

Hull lines: A set of related curves in three views which describe the complex three-dimensional shape of a vessel's hull.

Keel: The large, longitudinal wooden timber(s) which provides the main support ("back-bone") of most vessels; the frames ("ribs") are bolted to the keel.

Keelson: The large, longitudinal timber(s) fastened inside the hull, over the frames, to provide additional longitudinal strengh; sometimes reinforced by *rider keelsons*, bolted above the keelson or *sister keelsons*, bolted beside the keelson.

Knee: An angular timber, often L-shaped, used to reinforce the junction of two timbers in different planes; usually made from a crotch of a tree where two branches joined, or where a branch or root joined the trunk.

Lateen-rigged: a rig believed to be of Arab origin comprised of a narrow, triangular sail set on a long yard which crosses the mast at an angle to form a fore-and-aft sail, with the upper end of the yard and sail extending forward of the mast.

Mast: A round pole, set vertically in a vessel for the purpose of supporting the yards and sails. Ships gen- erally carried three masts: foremast, the mast closest to the bow; mainmast, near the center of the vessel (the aftermost mast on a two-masted vessel); mizzenmast, the aftermost mast on a ship.

Midships bend: the broadest frame in a hull; also known as the master couple or dead flat.

Molded [moulded] dimension: Generally, the dimensions which change shape or are shaped by the molds; the timber dimensions as seen in the sheer and body plans; the terms molded and **sided** are used because the terms "thickness," "width" and "heighth" would be ambiguous with many of the curved timbers found in ship construction.

Oakum: Old hemp or manila rope fibers which have been tarred for use in caulking seams in decks and planking to waterproof the seams.

Parcelling: To wrap a rope with long, narrow strips of tar-soaked canvas to protect the rope from weathering and chafing.

Pay: to coat a seam or surface with a protective layer of pitch, resin, sulphur or similar product.

Pintle: A vertical pin, attached to a metal strap on the leading edge of a rudder, that fits into a socket called the **gudgeon** to form a hinge on which the rudder pivots.

Planking: The long, longitudinal wooden planks which are attached to the outside of the frames to make up the outer "skin" of a vessel's hull.

Pole mast: A mast or mast section made from a single tree, as opposed to a mast built-up of several segments.

Port [earlier, **larboard**]: the left side of a vessel, when facing forward.

Powder magazine: A compartment or space, almost always below the waterline in a vessel, for use in stowing gunpowder.

Provisions: The supplies of food, beverages and clothing carried aboard ship for the sustenance and support of the crew.

Purser: On a warship, a warrant officer in charge of ship's provisions and accounts; the captain or a senior officer may serve the function on a merchant vessel. (Also see **supercargo**)

Rabbet: A groove cut in a timber to accept the edge of another timber to form a strong, tight joint. The term generally refers to the grove cut in the keel to accept the garboard, or lowest, outer plank; the rabbet extended up the stem and stern posts to accept the hood ends of the planks.

Ribbands: Longitudinal wooden battens nailed to the outer faces of the frames and usually carried to the stem and transom; see also **Harpings**.

Rig: A term used to indicate the configuration of a vessel's masts and sails (e.g., "brig-rig"); "rigging" is the general term for the ropes, blocks, chains, etc., which support and move masts, spars and sails.

Room and space: the total distance from one floor timber to the next, including the width of the frame, the first futtock (if any) and the spaces between them.

Rope: Any type of cordage, above one inch in circumference, used in rigging and other shipboard use; includes hemp, manila, sisal and coir (the term "line" was not applied to ropes in the eighteenth century).

Round tuck: See **Tuck**.

Running Rigging: The portion of a vessel's rigging which is moveable and passes through blocks for adjusting spars and sails (e.g., halyards, sheets, etc.)

Sacrificial Planking: See **Sheathing**.

Sail: A configuration of segments of canvas or other material sewn together and suspended on spars to convert wind to motive power for a sailing vessel.

Scantling: The dimensions of the principal timbers and planks of a vessel.

Scarf [scarph]: An overlapping joint which provides a strong union between two timbers without increasing their length or other dimensions.

Schooner: A type of rig which developed in the eighteenth century, very likely in New England or the Chesapeake, and which grew rapidly in popularity. A schooner is a vessel with two or more masts carrying fore-and-aft sails, although they often set a square fore-topsail. The term is most often applied to a two-masted vessel with the foremast shorter than the main.

Scuttle: To purposefully sink a ship, usually to prevent capture in time of war; also an opening in a ship's deck, hatch or side.

Serving: To wrap a material such as small lines, leather or canvas around a rope to prevent fraying, weathering and chafing; often the served rope is tarred.

Sheathing: A thin covering of wood or metal in tended to protect hulls from marine organisms, including shipworms and fouling growth; wooden sheathing was used until the late eighteenth century when copper began to come into use.

Sheave: The revolving wheel in a block, generally made of Lignum vitae, a durable hardwood.

Sheave pin: The wooden or metal dowel which forms the axle upon which the sheave revolves.

Sheer: The longitudinal sweep of a vessel's sides and/or decks; a sheer plan is the side view of a hull plan.

Sheet: A rope or tackle used for trimming a sail to the wind; on a squaresail, a sheet is attached to each of the lower corners (clews).

Ship: Used in the generic sense, the term refers to sea-going vessels, as opposed to boats; as a description of a type of rig, it refers to a sailing vessel with square sails on all three masts.

Ships's stores: See **Stores**.

Shoe (false keel): a timber which runs the length of the keel and is bolted to its lower surface as an extra strength member and as protection for the keel itself.

Shroud: The heavy ropes used to provide lateral support to masts; shrouds are part of the standing rigging.

Shroud-laid: A rope made up of four strands twisted around a central core or heart; used for shrouds because it was less likely to stretch than hawser-laid rope.

Sided dimension: The dimension of the unmolded, or unchanging, surface of a timber; see also **Molded dimension**.

"Slops": articles of clothing carried on board ships for sale to seamen as needed; the term often included other incidental items as well, such as needles, thread, etc.

Snow: A vessel rigged similar to a brig or brigantine, and often called by one of the other names. Snows generally set square sails on both masts, but with a small "trysail" mast stepped directly behind the mainmast on which a driver or spanker was set, thus allowing a main squaresail to be carried. Sometimes snows used a rope "horse" instead of a trysail mast. Generally the snow was the largest Eurpoean two-masted vessel.

Spar: A general term for all rigid supports used in the rigging of sailing vessels; it includes masts, yards, gaffs, booms, etc.

Splice: A method of joining two ropes together or forming a loop or "eye" in a rope by unlaying the strands and intertwining them in a specified manner.

Spun-yarn winch: A small wooden reel used for twisting two or three rope-yarns into spun-yarn, which has many uses on the rigging of a vessel.

Square-rigged: A vessel with one or more masts with a sail or sails set on a yard(s) perpendicular ("square") to the mast(s). See also lateen-rigged.

Square tuck: See **Tuck**.

Standing rigging: The parts of a vessel's rigging that is fixed and supports the masts, e.g., stays, shrouds, etc.

Starboard: the right side of a vessel, when facing forward.

Stay: The heavy ropes used to provide fore-and-aft support to masts; stays are part of the standing rigging.

Stem (stern) perpendicular: Imaginary vertical lines drawn at specified points at stem (bow) and stern to assist in defining the length and tonnage of a vessel.

Stores: Those materials required for self-sufficient operation, maintenance, communication, protection and repairs, and care and sustenance of crew and passengers.

Strake: One continuous line of planks all the way fore and aft.

Supercargo: In merchant ships, the officer charged with the accounts of the cargo and all commercial transactions during a voyage; the supercargo was answerable directly to the ship's owner.

Tar (pitch): Residues of the distillation of pine tree gum, used as a protective coating on standing rigging and ropes of all types; pitch is a mixture of tar and coarse resin which is mixed with oakum for cauling seams.

Thimble: A circular or heart-shaped ring made of wood or metal around which a rope is spliced to form an "eye."

Timbers: In a general context, any wooden hull members; usually referred to those members that formed the frames of a hull.

Transom: One of the horizontal athwartships timbers, fixed to the sternpost, that framed the shape of the stern.

Treenail (trunnel): a wooden peg or dowel, round or multi-sided in cross-section, used to fasten timbers and planks together; treenails were driven into holes that were pre-drilled to a slightly smaller diameter, resulting in a tight fit.

Trestletrees: Wooden timbers attached at right angles to the crosstrees to give them support and to secure mast sections together.

Truck: A piece of wood that can be conical, cylindrical or spherical, depending on its function. Parrel trucks were globular and had holes drilled through their centers so that they could be strung on a rope to form a parrel for securing yards to masts; also, the wooden caps fitted at the top of masts through which signal halyards are often passed over sheaves; also a term used for the wheels of gun carriages.

Tuck: The location at which the ends of the bottom planks terminated under the stern or counter. When the planks ended in a convex curvature, it was known as a round tuck; when the stern and counter were perpendicular to the posts, it was known as a square tuck.

Tumblehome: The inward curvature of the upper sides of a vessel, above the level of the maximum breadth; curving the sides inward, thus reducing the ship's beam at the upper levels, reduced topside weight and improved stability.

Wale: A thick strake or belt of planking, running the length of a vessel to add strength and stiffness to the hull; large ships often had several wales.

Windlass: A horizontal cylinder, supported by heavy cheek timbers, around which anchor cables and hawsers were wound to raise an anchor or haul a rope; similar in function to a capstan, which is oriented vertically.

Worming: Passing a small line spirally into the lays of a rope or cable for strength and to smooth the rope for serving or parcelling.

Yard: A spar upon which a squaresail is set.

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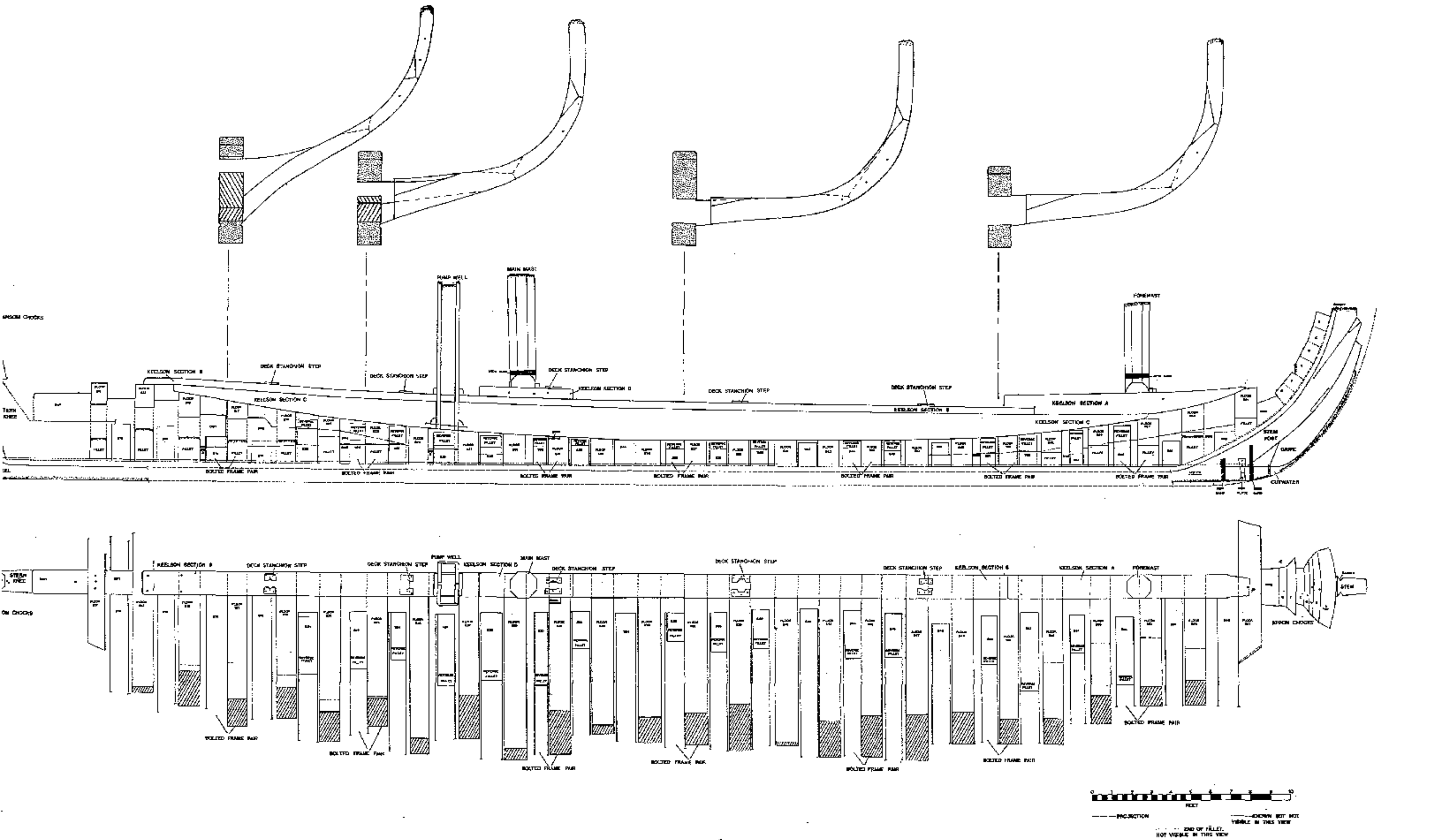

Plate I

The *Betsy*: Plan and Profile, showing principal timbers

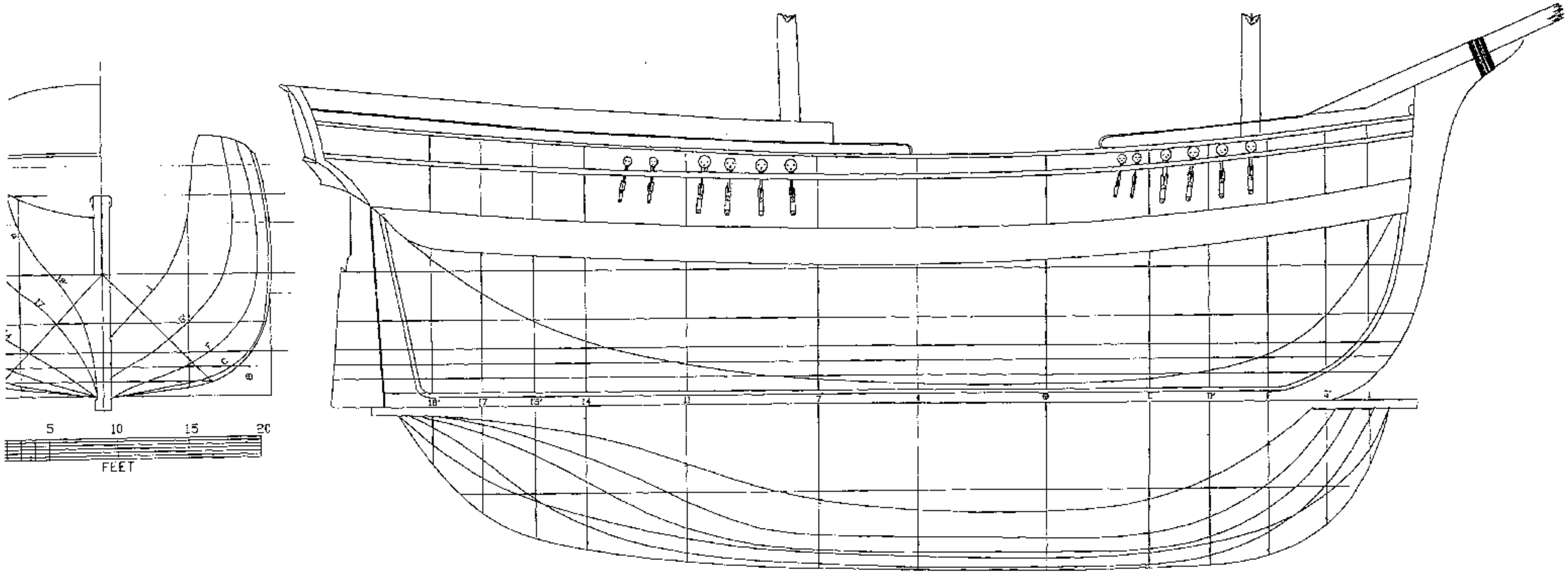

Plate II

The *Betsy*: Reconstructed lines drawing

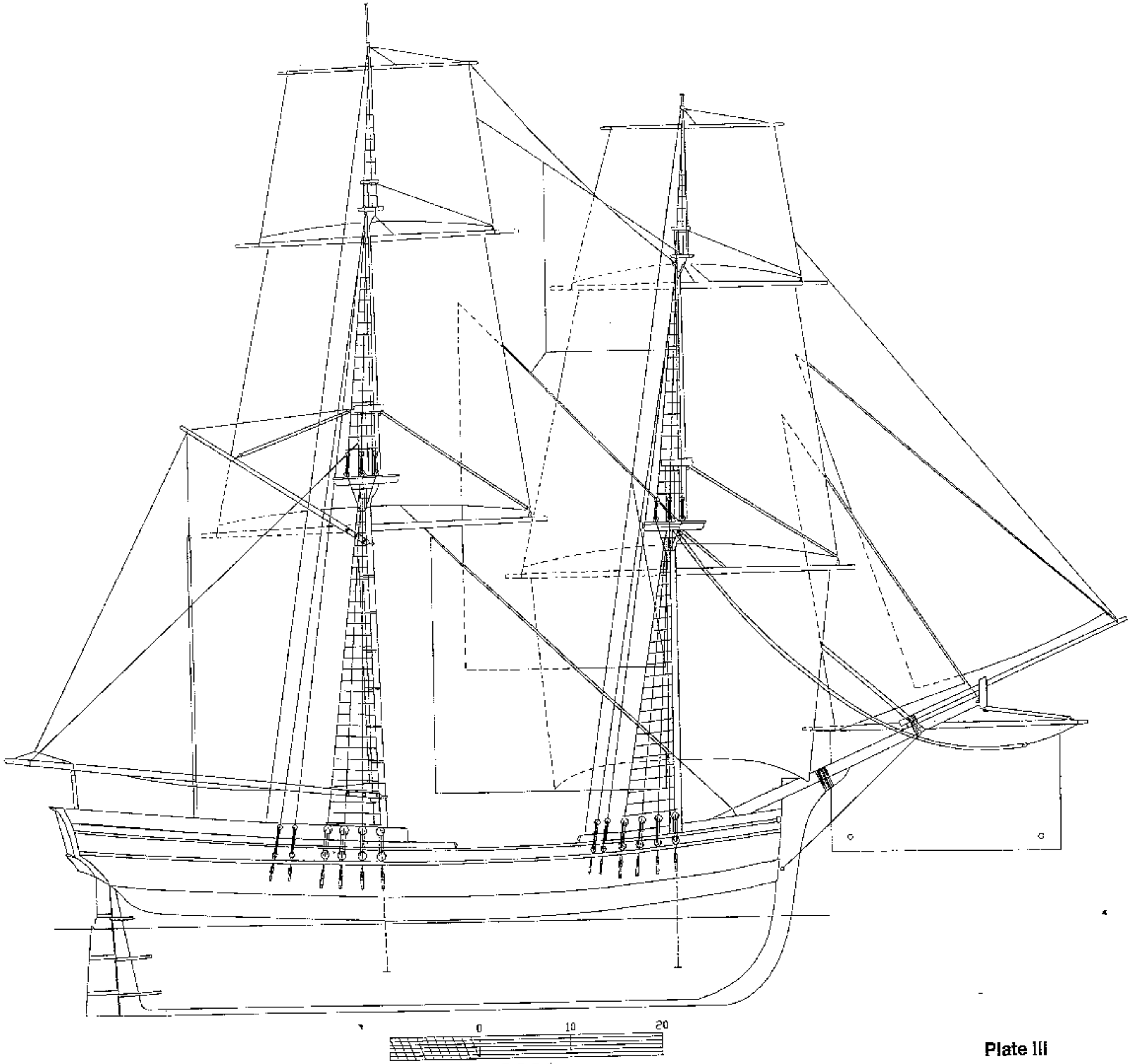

Plate III

The *Betsy*: Final reconstruction